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PSYCHOLOGICAL OPTICS

BOOK II

SAMUEL RENSHAW, M. A., PH. D.

P S Y C H O L O G I C A L   O P T I C S

by

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—BY—

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OPTOMETRIC EXTENSION PROGRAM

LEARNING
(Part II)

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A little more than a year has passed since the last paper in this series was written. That paper undertook the ambitious task of attempting to put in the form of some "safe" generalizations the results of numerous studies by many investigators of the problems of learning. This was not an easy or a very satisfactory thing to do. It has already been emphasized that learning theory is still far from settled. In any young science this is always a sign of good health. As experimental evidence accumulates and the facts come to light, it matters little that some hypothecation highly favored by one or more scholars has to be scrapped. The net result of such a process is greater agreement, not only upon specific questions but also upon more fundamental matters. As a case in point, there was a time a couple of decades ago when the conditioned response theory was looked upon as the basis of experimental methods which would carry the solutions for practically all important psychological problems. Without questioning the positive contributions of the many experiments which arose as a result of the early work on conditioning, it is a fact that there have had to be made rather extensive changes in attitude and practice so far as conditioning is regarded as a basic principle for learning. So it is with almost every attack upon an involved problem.

We must realize also that among scholars and members of learned professions which we might reasonably expect to have a certain sympathetic and understanding interest in the problems of learning and in the things being done about them, there is often a surprising lack of information and often open antagonism. An otherwise well trained biologist, for example, will agree that one function is highly susceptible to practice effect and vigorously deny it to another function equally trainable. I have letters in my files from people who have been advised both by optometrists and ophthalmologists that any form of visual training will certainly end in failure. There are many other documents in the same files which can be presented as convincing proof to the contrary. Our most important concern should not be to assume responsibility for the education of those who have not availed themselves of the existing literature of science. The right to express authoritative opinion is predicated upon sufficient work, training and first hand experience in any field that it may be said this right has been earned.

Our proper concern is with the many problems which center about what to do and how to do it. Here in this laboratory, we have worked for a number of years in the field training persons to perceive visual forms in short exposures. One very interesting and important phase of this problem is question of limits. What is the limit to which an average person can be trained to perceive visual forms? The answer to this question is: We do not know. Thus far we are only prepared to say that the question can only be answered after we have found the answers to several other questions, which at present we believe are essential to the question of limits.

If it is argued that "acuity" is anatomically fixed and cannot be increased by training, then I must reply that if the speaker insists upon adherence to purely anatomical definition of "acuity," there can be no argument on this point. But if an observer is only able to separate and resolve a pair of black parallel bars on a structured ground at 4.5 meters today and three weeks later he does the same visual task readily at 7.5 meters, this man, through training, sees in a fashion for which he was incapable at the start of the training, call the effect by what name you will. Let the skeptic train a half dozen subjects himself, following standard procedures and carefully analyze his data and he will, if he is not utterly incompetent, realize that he must greatly change his

notion of the meaning of "acuity." For it is literally shot-through with the whole matter of the visual perception of form. And more, postures and various and sundry effector processes which both precede and follow the resolving act are powerful determinants of resolution as he may see if he will but look. And so the "simple" problem of measuring or training "acuity" quickly turns out to be something not simple at all. It calls for more research, investigation, clinical observation; the problem is open, not closed and settled.

Learning is one means of achieving an equilibrium of internal and external surrounds. Death is another, sometimes more, sometimes less satisfactory method. The incubus to learn comes from the failure of existing behavior mechanisms to bring about a biologically and psychologically satisfactory equilibrium when a sufficient "external" change is met.

The external change may take a wide variety of forms. It may mean the procuring of a new source of foods or the devising of a new means of protection from enemies. It may be of such character that it cannot be disregarded or it may be a change of the type over which the reactor may exercise an option. It must be clear that the kind and amount of reorganization of behavior patterns is not only a function of external procedures, but also of the traces, interests, attitudes, sets, etc., which the results of previous learning, added to the basic organic make-up of the individual, are strongly determinative of the ultimate outcome. The basic mistake made by many critics of learning theory is the disregard of this double character of the process. It is relatively easy to see from these considerations why there should exist a relatively low correlation between learning and literacy, and likewise it is easy to see why there should be a much closer relationship between literacy and learning. Linguistic skill may be not the most important component in the acquisition of many other skills.

Let us add a few more generalizations to the list begun in the preceding paper.

17. Learning and performance are not covariant.

True learning can only be deduced from the analysis and synthesis of performance data. Performance can change in either direction, namely toward improvement or decrement and no change whatever take place in learning. Likewise learning may go on continuously while performance stands still for a considerable period.

Many things which influence performance either positively or negatively may have no effect whatever on the ultimate amount, rate and form of learning.

It is not unlikely that true learning is a sort of conceptualization of improvement and as such it is a form derived from a sort of mathmatical abstraction or variation from performance data.

Based upon considerations of this type we may postulate that

18. The rate of learning for any skillful act is a constant. This is but another way of saying that if we plot the curve of improvement by expressing the logarithms of achievement as the ordinates and the logarithms of the practices as the abscissae, we usually secure a series of points which determine the slope of a straight line of small gradient. This slope defines the rate of learning. We have seen numerous instances of it in our laboratory in a number of different types of the acquisition of skills. Insofar as this is a true state of affairs, it means that the conception that improvement is much more rapid in the early stages of learning and slower later is not founded in fact. While performance may change in such fashion, yet the rate of improvement is constant, and one learns just as rapidly in empirical units later in the practice series as compared with improvement in the first stages. If this finding is substantiated, it means that in the later stages of the acquisition of skill when practice sessions can be increased profitably, the same rate of absolute improvement holds.

19. Just as the rearranging of subgroups is an important part of the formation of any habit, so likewise forgetting or the disruption or degrading of old habits or weak and inexpedient habits is frequently a necessary first step in making the way clear for newer and better achievements.

It often sounds paradoxical to say that the way to learn is first to learn to for-

get, but this process of repatterning is sometimes only accomplished by the dropping out of items in a series which perform no useful or important function.

Consider, for example, the problem presented by the visual rehabilitation of an adult who has perhaps for twenty years daily been exercising a function not only wrong in itself but detrimental to other visual achievements. Cases in point are the squinter and the myope. The replacement with new order habits or skills will naturally be slow and sometimes difficult.

20. In true learning there is always the replacement of a weak, tense or unstable pattern by a smooth, effective, stable improvement of a different form.

True learning is not a mere addition of new movements nor a subtraction of parts of older ones, although the dropping out of part movements does take place. Rather we should regard this as part of the larger and broader reorganization of the total behavior pattern. The trend is toward unity and simplicity.

Frequently direction is given to the course of improvement by the essential ground of motivation which may exist as a purely rational set, attitude or predisposition; or as this plus a strong affective or emotional component. Control of learning always involves the giving of careful attention to the matter of the proper control of motivation. It is always a difficult thing to know just when and how to manipulate this factor.

21. There are three procedures for the effective breaking of any habit: (1) Remove the instigating stimuli from the environs of the reactor. (2) Apply the principle of experimental extinction, which was discussed in previous papers dealing with the conditioned response. (3) Train the reactor to make a new and more acceptable response to the same stimulus conditions.

It is likely that a fourth procedure may be found in those instances where we must replace an inexpedient function with a more suitable one. In perceptual training, for example, we may be limited by the size of groups and must resort to the utilization of larger sub-groups in order to provide for improvement. Since the amount of habit interference usually is a function of the degree of virtuosity attained in the learning of that habit, it is not necessarily true that old habits are stable merely as a function of age. Internal organization may be far more important and such facts account for the rapid and permanent disruption of habits of long standing. (cf. for example Kotona, G. Organizing and Memorizing).

22. There will be little or no interference if the first habit is carried to a high degree of skill before the second is started.

23. Habits may be specific or nonspecific; abstract and general or narrowly specific.

It becomes especially important to realize that in all visual training work, it is highly essential to keep in constant touch with the state of progress of each individual learner. The task of the operator is merely to arrange conditions suitable for the learner to train himself. Many motivational problems are solved automatically by the simple expedient of giving the learner some responsible function to perform from the very first.

It is, of course, impossible in brief compass, to deal adequately with so important and so extensive a topic as learning. Subsequent papers will have to do with a specialized form of learning, which is called perceiving. A list of references was given in a previous paper covering the general problems of human and animal learning.

Psychological Optics
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PERCEPTION

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Perception is a word of great importance. This paper is the first of a series in which we shall present some of the facts about how we perceive things and processes, space, time and motion.

There has never been a time when philosophers and scientists have not busied themselves with some phases of the problems of perceiving. It was written that "Esse est percipi" -- to be is to be perceived. The key position of the problem of how we perceive, understand, know, appraise or classify our worlds as we experience them needs no argument.

Perception at the hands of Locke, Berkeley, Hume was one thing. Then Kant raised certain questions about space, and thenceforth the problem took a new direction. He saw that to perceive space we must extend beyond the impressions immediately given by the sense organs; that the functional process of perceiving could not be limited to the temporal present - a fact which had been used and still is used in some quarters to distinguish perception from recollection (past) and imagination (future).

It was about this time that mathematicians began to examine the concept of space-experience critically. The axiom that the sum of the interior angles of a triangle equals two right angles was questioned on the ground that the truth of such propositions is contingent solely upon the fact that the law holds only if regarded within the particular space of our impersonal common experience. It soon became apparent that there could be dozens of spaces - some of them bizarre in comparison to the common notions of the common man.

Not only have numerous non-Euclidean geometries arisen, such as topology for example, but it is important to note that out of these imaginative projections have arisen many important practical scientific discoveries which in all probability would not have appeared had it not been due to the expanding concept of space as a personal psychological relation.

It has never been easy to define and limit the concept of perception either historically or now. It has never been difficult to realize its fundamental importance. For all who work with visual problems it is safe to say that it is today an active frontier. The molar conception of eye care and training leads us directly and inexorably into the problem.

To perceive we must always perceive something. There is always the actor, the perceiver and the thing acted upon or perceived. The act is one which maintains or restores equilibrium. It puts the organism in command of a more favorable position in relation to his surroundings. It enables him to identify, classify, name or adopt an attitude which is preparatory, prodromal and as such shows us part of the mechanism for the long section unity and continuity of experience. Unity and continuity of the perceptual process is its most general feature.

Even in the behavior of the lower organisms we may observe the crude first beginnings of the process. Here it does not occur to us that there should be introduced any sharp division between the continuous stream of adaptive responses and the more elaborate versions of the same process when millions of years of evolution have produced better eyes, brains and effector organs. The difference seems merely to be one of degree, not of kind. From the earliest contact excitations and adaptive movements what could be more logical than the evolution of distance receptors, with the consequent period of delay between excitation and reactance? Such a state provides for the concept which Dodge has called variability in behavior. The search for meaning is the search for the expedient way out. Learning is only thus a longer and more elaborate means of conserving or diminishing the energy output demanded for

some biologically or psychologically satisfactory solution to the upset equilibrium imposed by the failure of the present bio-social relation to maintain itself at some specified future time.

The essence of the process of perceiving thus is motor - its being lies in movement, adjustment, the restructuring of the total field of the behavioral environment.

Many years ago G. F. Stout wrote as follows: "Perception of physical reality always arises in essential connection with the experience of active movement." And again, "Only those experiences which determine adjustment have an objective reference." These statements were written forty-five years ago. One wonders why scholars did not understand them in their full significance; why following this trail to the bitter end was not undertaken. Had it been so we could have avoided the wasteful and unproductive arguments over epistemology and the wasted effort of scholars waging acrimonious warfare over the categorical names to be pasted upon functions rather than the careful study of the functions themselves and their operational relations.

Only comparatively recently has the importance of the role played by the perceiver come to receive its proper emphasis. A battered alarm clock is ticking away in this room as I write. I can <u>hear</u> the stream of ticks as patterns of two's, three's, four's, or as six's, seven's, almost anything. The clock and I together can fill <u>this</u> room with whatever structured pattern suits my fancy. But the deadline was yesterday - and almost every tick says "hurry, hurry, hurry!" The molar environment, invisible to the man in the next room who wonders why I elect to work so hard and so fast on such a warm day, is uncomprehended by him. It is nonetheless a powerful determinant of the course of events. It can revise, extend, suspend the total relation of the <u>me</u> to my surroundings.

The late William Stern wrote that "It becomes manifest that within the sphere of perception the Gestalt represents only one terminal pole of a series of states, at the other pole of which is the undivided unity of the person. It is the series that ranges from maximum salience to maximum embedding. Gestalten are simply the most salient phenomena of perception." (<u>General Psychology</u>, McMillan, N.Y., 1938, p. 115). Later we shall have much to say about this process which Stern calls embedding and disembedding. Such a quotation does not minimize the great contributions to perception made by Wertheimer, Rubin, Kohler, Koffka and others. Stern is cited merely to indicate that an overwhelming importance attaches to the contribution to perception made by the perceiver himself.

To the physicist and the physiologist the words training to perceive often carry an oversimplified connotation. A little can be done, they freely admit, but not much. What is done is the grossly simple matter of a purely "mental" change in outlook, frame of reference. They seem grossly unaware that perceptual reorganization is a fundamental recasting of movements, transforming the whole active process of give and take into something radically different. The tyro and the virtuoso stand at two opposite poles, live in two different worlds, in reality.

I cannot subscribe to this sort of finalistic thinking. It stops investigation. If we can show that the modern view of the problem as we are able to work it out for ourselves contains the germ of great potential future developments, we may be playing the role unwittingly in our sphere played many years ago by those courageous mathematicians who dared to deny the lifeless limitation of a single, oversimplified Euclidean space. Or, like Victor Hugo, it may be that "new things may be either constellations of profundity, or stars made by duck's feet in the soft mud of the pond."

In 1880 G. Stanley Hall in Boston "understood ... the making out of a list of questions, suitable for an inventory of the contents of the minds of children of average intelligence on entering the primary schools of the city." Ten years earlier Bartholomai did the same thing in Berlin. Later Greenwood did likewise in Kansas City. Since then Stern, Whipple, Foster and others have repeated and extended these observations. How sound and true is a child's perception of his world at the age of entering school?

The results of the above investigations were as surprising then as they are now. "Skeins and spools of thread were said to grow on sheep's backs or on bushes ... butter came from buttercups, flour was made from beans, oats grow on oaks, trees were

stuck in the ground by God and were rootless. Cows say 'bow-wow,' pigs purr and burrow ... while no one child has all these misconceptions none are free from them. A child who knew much about a cow, its milk, horns, leather, meat, etc., was yet sure from the picture book that it was no bigger than a small mouse."

Fortunate is the child who selects parents who will provide him ample opportunity in early childhood to build a wholesome familiarity with the legion of simple mechanical principles, and with the sights, sounds, smells of the ordinary and commonplace things he must know before the age of puberty.

College students have been found equally uninformed about many simple facts in nature, history, the arts, etc. Not long ago I asked a group of senior men whether the stomach is found above or below the diaphragm. The answers were about equally divided.

Bartlett studied some semi-savage races in Africa. He found that those who live as cattle raisers and herdsmen built their systems of counting, economic values and even moral concepts about the familiar everyday symbols of cattle.

The exploration of the reference frames of patients should be a part of the first steps in perceptual rehabilitation and training. The visual perception and reproduction by drawing of so simple a figure as an isosceles triangle may be quite a difficult task for the adult whose whole visual habitus has been foreign to this sort of thing. Seeing common objects in correct size, position and form relations is correlated with groundal impressions of weight, texture, movement and mechanics of these same objects handled, lifted or thrown countless times from childhood. "Reading readiness" is a euphonious way of indicating the repertoire of such associated movements capable of giving contextual meaning to the artificial and arbitrary visual symbols used to represent them. Our eyes have been evolving for three million years. We had reasonably good eyes long before we had an ear capable of sound-symbol detection. The eye thus has supplied the distance receptor correlates for countless numbers of associated movements, postures, etc., and the basic ones of these are laid down very early in life. They are the grounds in which are embedded (to use Stern's term) many of the figured experiences which in adulthood must be made to achieve figure-status by intelligently directed means.

Form thus can be seen to be interdependent with space, and we can see how, frequently, training one function of vision may have a distinctly beneficial influence of the disembedding type on other seeming unrelated functions.

Finally let us not forget the observation of Binet: that the beginning of reasoning lies in the clear perception of all the conditions which relate to the problematic situation. The longest step toward its solution is the clear understanding of just what the problem is.

Psychological Optics
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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: II

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One of the products of several hundred million years of the evolution of the central nervous system has been the making of a mechanism which frees the organism from the limitation of life in the present. The "traces" left by previous experiences are combined perceptually with the projections into the future of anticipatory responses to produce the organic unity and continuity of experience. The act of perceiving is thus literally a synergizing function. It is not essentially different in form from the functions of reasoning and problem solving. Its primary business is the adequate and harmonious resolution of all the divergent impressions, drives, impulses, etc., at the moment. The end product is a commitment to some form of action which furthers the behavior interests of the organism. This may take any of a variety of forms, such as naming and classifying; assigning scale position of value; assuming an attitude of defense, escape or belligerency. The perceptual act is always based upon a foundation of empathy. The perceiver manipulates his world much as the chess player works out his serial moves of attack and defense as best he can in terms of the moves made by his opponent. It is this personal aspect of the active process which is one of its outstanding features. We are rarely aware of this important role of the self. Its importance has been repeatedly emphasized, e.g., by G. F. Stout and William Stern.

From such considerations we must conclude that training such a function must involve placing the perceiver in such a position that he must do something. He must pick up the sense-perceptual data of the present and synergize them into some form of satisfactory consummation.

I can think of no better example of the essential biosocial unity in perception than the experience of returning to clear consciousness after your dentist has given you a "laughing" gas anaesthetic. The first dim awareness is that you are in the midst of vague forms moving about but where you are is still undertermined. A trifle later you reach a stage of emergence from the disorientation and you see objects in the room, cars and people through the window, but they are ghostly unrealities. They exist in a world which as yet is not yours. Finally the self identification comes, often in an instant, and with it a complete and radical change in the whole picture.

In extreme fatigue, anoxia, strong emotion, intoxication, religious ecstasy and similar states, the profound alteration of behavior is always marked by the sense of personal detachment. Prolonged work on a finger ergograph of the Mosso type will lead subjects to report that the "fatigue" state causes them to regard their own right middle finger, hand and arm as an "object out there" not belonging to the self. In the extreme case reports have even led to a sense of complete personal detachment, in which the apparatus, the room, the experimenter--and the subject himself--may become radically transformed or even disappear.

In every case the onset of this sort of thing is preceded by a period of acute discomfort or pain. The mechanism of escape, suppression, substitution, sublimation, etc., comes into play. If some such solution cannot be hit upon, then we must regard the stage as set for some more active form of neurosis. When Pavlov's dogs were forced to discriminate beyond their limits of resolution the stage was set for the familiar "experimental neurosis" or artificial nervous-breakdown.

Can it be that the persistent and prolonged exercise of heterodyning visual functions likewise set the stage for visual forms of escape, substitution or suppression? What of the myope, the squinter, the amblyope? What of the child with low skills who cannot read understandingly? What is the

true etiology, the behavior life-history of these functional states up to the time when they are first seen professionally?

Since memory traces play so important a role in perceiving, let us look for a moment at this function.

The accurate reconstruction of what you saw, or heard or experienced is the unexpected thing. For what you retain and recall, is in the most cases, not what you saw or heard or experienced but what you did about it and what it did to you!

Do we all have poor, inaccurate memories then as the general rule? No, that does not follow. A trained individual learns the skill of getting the kinds of impressions which he wants and is able to remember. He learns the sources of error and so checkmates them before they become effective. How does he do this?

The answer to this question brings out a most interesting and important discovery about the first step we must all take when we wish to remember something. That is the matter of clear perception of the thing you want to retain.

Suppose you are interested in building a new home. I show you a picture of the front of a house which you admire very much. You study it carefully for five minutes. An hour or so later I ask you to draw what you saw or to answer questions about it. You know some of the things that will happen. We can make and have made many such experiments in our laboratory where we can control all such factors as the time of exposure, the size, position, color, shape and surroundings of the object and more important still, those psychological factors which mean essentially that by controlling how you look we shall control what you see or perceive. We learn that your drawing or report is often inaccurate so far as size, shape, position, direction, color, motion, etc., are concerned, but quite accurate as a representation of what you saw.

Seeing is an extended psychological form of handling or manipulating objects. We see whole objects primarily. Our impressions are total affairs and parts, such as the design or shapes of windows, doors, angles, shutters, etc., if seen at all, are seen at the expense of the suppression of other parts. Every artist knows that a face is not a geographical assemblage of eyes, cheeks, nose, chin, etc. To paint a face he must bring all the parts along as a unitary whole. Some parts stand out; are strong and suppress others. This is partly due to the nature of the parts themselves and partly due to the way we look at them, the skill we possess to see plus adequate frames of reference built up by training. Careful experiments have produced many important facts about this process. Its proper understanding is very important in teaching your youngster to read and to spell.

If you are shown a triangle with one of its angles truncated or omitted for a brief explosure, there is a very great tendency that you will complete the figure when you recall it. This is the phenomenon of perceptual filling. Missing parts or details are supplied. Simple things are seen, not as they are, but as they should be. Naming the thing seen gives us certainty and satisfaction if the figure is simple. With complex figures naming plays an entirely different role. Often in recall the retained process becomes completely transformed into something more closely resembling the concept represented by the name than the thing shown to us originally. In simple shapes we often remember that the thing is, frequently what it is or was, but more frequently forget where it is or was. This reconstructing of the patterns of experience is ever present in everything we see and do, and is of the greatest psychological importance.

Interpretation often, even in simple figures runs ahead of presentation. We always "see" more than is furnished by the stimulus, and much of what we "see" is not seen at all but is derived from other sensory and motor sources. For example, we say that a chunk of iron looks heavy. But nothing ever looks heavy. Vision is here borrowing from the muscles, tendons, skin and the surfaces of the joints. The act of perceiving or imprinting experiences is always an active process because we are absorbed in its content rather than its form.

By using appropriate exposure devices in the laboratory and by means of the twenty-one known methods of measuring the retention we have accumulated a large body of facts about the basic processes in memory.

We always look for poor methods of original learning when anyone comes to us about how to improve his memory. For experience has shown that this is one of the chief sources of trouble.

Oddly enough imagery plays a very minor part in good memory. Martin, Moore, Wulf, Piéron and others have shown that in the best cases of retention and reproduction, imagery is vague, fragmentary or entirely wanting. This, plus other facts, enables us to set down as a myth the popular notion of the "photographic eye" or the "photographic mind." Any camera, substituted for your eyes would soon be abandoned as a very bad thing. Mental life would become a hopeless chaos if it were furnished with static, exact copy images.

Everything that you learn and retain works in two ways to influence subsequent learning and memory. It works retroactively backward to reinforce or to extinguish earlier learned things, or it projects its influence forward in time (proactively) to help or to hinder newly learned things. Here similarity or identity of meaning is a most important factor. One sure way to hasten forgetting is to learn a number of things simultaneously which are closely similar in their psychological effects. This rule is often violated.

Memory can be greatly improved by learning to trust yourself. Taking notes, writing things on scraps of paper, tying red yarn around your finger--all such things are "crutches" and should be avoided. Give good impression a chance--and your nervous system will do the rest. As you develop confidence in your memory you will be repaid by its better performance. But, finally, do not expect that a whole new set of efficient mental habits can be formed overnight or by "six easy lessons by mail." Memory can be trained so that it will astonish you if you are willing to pay the price--which is (1) to work patiently and conscientiously (2) using proper methods, (3) over sufficient time.

Yes, memory can be trained, just as you can form any other habit. In the last few years we have studied this question experimentally at considerable length. One of our subjects was Dr. Salo Finkelstein, who was able to memorize long lists of numbers in our laboratory faster than any other person had ever been recorded. Faster, that is, until one of our own students was trained to equal and in some cases exceed the world records set by Finkelstein. Suppose someone gave you a telephone number like this: 7295310826844395. This number contains sixteen digits. It was memorized on 1.08 seconds, while twelve digits could be memorized on 0.537 seconds. Twenty-four digits took an exposure of 5.772 seconds. Thus while twenty-four is twice as long as twelve digits, it takes more than ten times as long to memorize it.

Any average person can be trained to do things of this sort with an almost unbelievable skill, provided he or she will use the proper psychological methods.

But "I have trouble remembering names and faces. How can I do that more effectively?"

Much of the inability to recall the name of the man you met and talked with last summer reduces to the fact that you did not take the trouble at that time to learn the name and relate it to the face.

The next time you are introduced, listen for the name and get it clearly. Repeat it, check it, verify it if necessary. Delay the visual size-up of features, clothing, habits of speech, business, the weather and all such considerations, giving the naming process time to register. Do not try to associate things. Do not use "systems." These will only hinder you. Practice in recall, several times in the first few hours, then occasionally thereafter. And remember that to master an apparently simple golf stroke is no simpler than the thing you wish to learn to do well.

Your memory is really a marvellous thing. It is a priceless treasure. Its dominant importance was clearly recognized by Shakespeare for the play-king in Hamlet said: "for purpose is but the slave to memory." You can learn to remember--and to forget--rapidly and effectively. It is an interesting undertaking for anyone. Cultivate this skill and you will make your mental life richer and more effective and also more pleasant.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: III

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The act of perceiving is consummated in naming, handling, classifying or ascribing value, rank, or significance to things or processes. The cognitive phase of the perceptual act is always secondary to the motor consummation. The earliest and simplest of adjustory movements of the protazoan are just as much to be regarded as "perceptual" as the more involved problem-solving activities of men. The differences arise from greater limitation to the present in the case of the simpler animals. Their behavior repertoire is less varied. Linkage with past and future states is far more limited.

As receptor organisms evolved and through enforced training became highly differentiated, variability in patterns of both excitation or impression and responses were increased. It is thus that the stage was set for learning or selective resolution among the behavior vectors. Perception thus must be regarded as a primary phase or episode in the continuous stream of adjustory movements. Its main function is to set the organism to responding in ways which are for him biologically and psychologically expedient. There is no essential categorical difference, therefore, between perception and learning except perhaps that learning runs a longer course in time. In either case, the essence of the whole series of events comprising a perceptual or learned act lies in its motor character. The sensory or impression aspect is, in itself, a form of energy impact tending always to be more and more closely linked in time with the consummatory movements. As early as 1896, John Dewey cited that the so-called stimulus to any motor response all must lie inside and never outside the act. All sensory functions are in reality motor functions.

The major part of the history of perceptual theory is concerned with the sensory and the cognitive or interpretative aspects Such theories as the context theories of perception were intimately bound up with atomistic association theories. Percepts were regarded as aggregates of separate simple processes bound together in some poorly understood manner by the mystic principle of association. Such principles were beset with two difficulties. First, upon examination it was found that all percepts have as their first and principal characteristic, essential and individual unity. Upon analysis they immediately lose form quality and therefore all significance. Second, it is impossible to follow rigidly the formula of the context theory in the laboratory to produce the synthesis of the unitary percept by the artificial combination of its alleged parts. The problem of meaning under such conditions became increasingly troublesome, since in such instances, its only source was a derivative of the contextual surrounds. It was difficult to see how meaning denied to the nuclear portion of the pattern could be derived from the fringe of other "sensations and images" of the same qualitative kinds. The early recognition by Helmholtz and Hering of the facts of color, brightness and form constancy, and the observations of Berkeley, Kant and Ernst Mach on space, particularly visual space, together with important developments in experimental biology pointing to strong emphasis upon the organismal hypothesis, all acted to turn the trend of thinking away from the over-simplicity of the elementarism and associationism of perceptual theories.

The origin of non-atomistic thinking with regard to perception is not an invention of Gestalt theorists in psychology. It is true that Gestalt psychology has made extremely important contributions to our better understanding of this province of knowledge. It is also true that those who have pioneered in this field realize perhaps more clearly than the rest of us,

that the Gestalt theory needs the testing and sifting which can only come from extensive research, before the final truth can be written. This is always the way of scientific development.

No other group of scientists working on perceptual problems has done more to establish a clean cut working hypothesis. To Ehrenfels, Rubin, Wertheimer, Köhler, and Koffka we owe a great debt of gratitude. From these men and their students, for example, more than 140 laws or principles regarding the process of perceiving have been established. Most of these principles deal with field structuring in perception and consequently can be reduced to about a dozen generalizations. Helson has done this job and with some slight changes let us review and summarize the principal facts.

Whenever the fields of the two retinas are excited by a visual pattern, the masses of form are not all equal in impression value. The field tends to become structured and those things which can relate to one another do so. Due to such factors as size, brightness, position, movement, appurtenance, etc., the field will be actively resolved by the perceptor into its best possible form which conditions will permit. This fact is principle one.

2. The principle of such field structuring is that of a figure set in or on one or more grounds. Figure is the coherent or salient portion of the pattern. The portions comprising fore- mid- and backgrounds are the supporting framework for the figure. Ground always plays an important role in figure organization. The distinction between the figure portions of the perceptual field and the ground is always in operational terms Figure behaves differently in perception, retention and recall.

3. The structural organization of a perceptual field will vary with the degree of appurtenance or articulation which it possesses. If things belong together they thereby achieve intrinsic strength and saliency.

4. Forms may be good or poor. A good form is good because of the degree of structural organization it possesses. Because of this fact it has high impression potency, resists distortion, persists, and is easier to recall.

5. Forms likewise may be strong or weak. A strong form has a sort of inertia which enables it to resist reduction by analysis or fusion with other forms which would cause it to lose its individuality.

6. Closure. Whenever a form approaches a stable equilibrium it has achieved closure. Before this state is reached it will tend to change in the direction of more and more stable organization. If, for example, part of a figure is shown, the perceiver tends to fill in or supply the missing portions in order to round it out for more achievement of stable form.

7. Forms are instances of field dynamics in the sense in which Faraday used that term. The field in such a case is an intricate sensory-cerebro-motor pattern. The constant flux of the course it runs is more determined by what the organism does than by the physical properties of the instigating stimulus pattern. Left to themselves, complex forms tend toward simplification. Weak patterns are fused or amalgamated with stronger ones. Closure, suppression and enhancement are constantly going on.

8. Forms tend to maintain themselves and the reappearance of a portion of a previously experienced field tends to reinstate in all or in part the original form. The degree of persistence will be dependent upon such factors as stability and strength of organization.

9. Constancy. Forms tend to maintain and preserve original size, shape, brightness, color, etc., in spite of the fact that they may be experienced in a new setting unfavorable to the maintenance of these properties.

10. Fusion. Two or more forms may fuse giving rise to a new shape different from any of its constituents. The weaker and more poorly articulated, the greater the likelihood for fusion. The more meaningful a form, the greater is the likelihood of its dominating less meaningful ones.

11. Position. Things close together in space and time and similar in other properties tend to combine into more stable structures.

12. Balance. Forms tend toward proportion, balance, and symmetry. In pictorial

composition the presence of an extraneous item weakens the entire structure. Curved lines are always perceived straighter than they really are. Most of the so-called geometrical "illusions" are instances of this principle.

13. Meaning and empathy. The search for meaning always begins with the moment of impression and continues as far as it can. The more meaningful a form, the stronger it is, the longer it persists, and the more easily recalled. Empathy means that the forms are identified with significant structures of the previous personal biography.

14. Embedding and disembedding. Forms and meanings emerge from the primary massive or undifferentiated state by a process which Stern and others have called disembedding. This process may be regarded as the mechanism that will help portions of the total field achieve figure structuring.

15. Transposition. Forms exist independently of their constituent elements and may be transposed without change to other elements. A triangle, for example, is a triangle whether it is drawn with heavy or light lines or dots. Révész trained chicks to peck grains of corn from the larger or brighter of two gray papers, regardless of size or brightness. This principle is of great importance and wide application. It means essentially that the original state of a form is abstract and generalized and exists independent of the content. It is upon this law that we base one of the most important principles in all visual training, namely, that the formal skill is set up independently of content and in consequence is transposable.

The formulation of such a law places the problem of the general versus the specific character of habits upon an entirely different experimental and theoretical basis than the empty and meaningless concept of the "transference of training."

In visual training one of our main objectives is the re-structuring of perceptual fields. To do this we must literally bypass the eye itself in order to create within the central mechanism a new pattern of field dynamics which may impose back upon the retina the necessity for better form or structure. It is entirely probable, for example, that in acuity training this is what takes place.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: IV - FORM

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The perception of a simple form is a very complex function. Gibson showed that if a sector representing part of a circle is shown tachistoscopically, say with an exposure of less than five milliseconds, an observer will see the line less curved than it is in fact. He "sees" the curve as straighter either as exhibited by his drawn reproduction or by his selection of a matching curve from a graded series. If a meaningless shape, composed of four or five straight and curved lines, is shown and the figure is re-exposed and re-drawn until a replica of the original is secured, a surprising number of exposures is required. If the observer is untrained he will master a part of the total form, only to lose it on the next exposure and later regain it. He sees analytically, piecemeal, disjunctively. Only as he eventually achieves a certain unity of form - as the visual field is structured to give proper relative position and emphasis to its constituent components, does the observer really "see." This is a process of highly intricate internal and external organization. Form is an adventitious artistic achievement. It has to be generated and perfected from simple beginnings. Every visual form is more surrogate and redintegrative than we are accustomed to think. Before form there must be the skill to see small differences and likenesses of brightness, position, size, and movement.

For years it has been clear that vision alone does not and cannot produce stable, sharply etched forms, since from them we cannot subtract the contributions of posture, of the skin and kinaesthesis, and of the vestibule and the cochlea.

It is virtually certain that visual form is, like melody, a unity by virtue of the fact that it too must run a course in time. It must conform or cohere to the schemata (Bartlett), the set, frame-of-reference, the prodrome, for these things are strong determinants of form. The process must thus be capable of foreshortening, of being telescoped or condensed. In direct apprehension we have examples of this sort of thing.

Form thus becomes the name of an intricate perceptual process more fundamental than content. To train and develop it properly we must arrange all the conditions which are most favorable for it. Some of these are known. Many are unknown. When we restrict the time of exposure we not only initiate the trend toward unity and coherence in the pattern of the visual field but we bring the observer more and more to the point where he depends less and less upon the external conditions of impression in order to perceive.

When we seek to extend sub-groupings into larger unities we virtually reduce the length or amount of the material and increase the certainty of the instant appraisal of the lattice, so highly important in the highly skilled operation of the trained perceiver. To illustrate this point concretely, suppose I show within a field a 12-letter unfamiliar word or a 12-digit number. The grouping pattern will be highly individualistic, but also subject to space, size, and other qualitative relations inherent in the context. Grouping-by-threes often become sixes and pari passu there is an immediate awareness of any violation of the formal set-structure or schema for "twelve-places." Content may be present but out of position. Form is therefore wrong. For example, suppose we show 2 9 5 8 3 1 4 6 5 8 2 9. We may get a reproduction such as 2 5 9 8 3 1 4 6 5 9 2 8. Such a case illustrates the primacy of form. It is the kinetic pattern of organization within the total external-internal field. All the digits are correctly reproduced. If we examine the inversions or position errors of several such instances from the same observer, we

may deduce much as to his manner of grouping, phonation, fixations, and may watch the change from day to day of the increasing formal organization. To appreciate such skill have someone type any 12-digit number on a 3 x 5 card. Hold it in your palm and give yourself about a 0.6 second look. Write down all you saw. Take another similar number and with a friend timing you, take as much exposure as you feel you need as the minimum to give you a correct reproduction. Check and compare the two. Training an observer to an adequate degree of skill in reproducing digits, consonants, or geometric forms will develop the "feel" and assurance for form. This will be transposable. Reading and spelling will increase by leaps and bounds. "Macular" seeing will take on a new meaning.

Detwiler has pointed out that the development of the macula and its projection areas was an all important factor in the evolutionary expansion of the "visual" cortex. Such structural increase was a necessary forerunner to the development of linguistic and similar signaling systems which form the groundwork of human culture. This is one chief reason why it is so pathetic to see children grow into chronological adulthood with large fractions of this precious potentiality left lying fallow and untrained.

Theoretical and experimental discussions of the many aspects of the form problem began about fifty years ago. Particularly prominent names in the early history of this problem are those of E. Mach, E. G. Husserl, C. Von Eherenfels and particularly F. Schumann. The work of Schumann published in 1900 is singularly modern in tone and certainly was instrumental in laying the groundwork for the appearance of certain portions of the perceptual theories of the later Gestalt psychologists. It is not our province to review in detail the history of this extensive experimental theoretical literature. More recently numerous workers have tried to put to the test of experiment certain of the theoretical principles laid down by earlier theorists. It is probably true to say that the whole problem of visual form is still in its infancy and consequently there will be quarrels and ambiguities over definitions, terminology, and the formulation of theory.

One of the most fruitful lines of approach to the problem is the development, mainly during the last quarter century of motor theory. The essential role played by posture and movement has of course been recognized for some time. Nuel, Musatti, Judd, Goldstein, Purdy, and others have contributed to this point of view which states that all visual phenomena have a dynamic or motor basis. The factors of impression are not the determinants of the course and end of perception but rather action patterns, determining tendencies and impulses to movement. Purdy has pointed out that the perception of space is ultimately determined by motor orientation tendencies, by the central arousal of motor impulses. Different objects in the visual field may rise simultaneously to opposing motor impulses. The localization of objects in relation to each other is determined by the differences between the directions of these conflicting orintation tendencies. It is this rivalry which determines whether a particular simultaneous pattern is conceived as a unitary whole or as an aggregate of disconnected parts. The stronger the rivalry, the weaker the coherance of the phenomenal pattern. The weaker the rivalry, the stronger the coherance.

Schumann showed that phenomenal objects in the visual field may change with shifts in the direction of attention. If one eye is hooded and a single point source is seen and the observer is instructed to look for the appearance of a second point eccentric to the first, a monocular diplopia may be observed. Purdy also noted this same effect. One of his observers particularly had no difficulty in discerning the doubling of real objects in the visual field. Purdy says that "the impressions of the fovea appear at the place where attention is directed, and all other impressions in the field change their apparent localization correspondingly."

This phenomenon which has been called the Schumann-effect has most important theoretical consequences. It means, for example, that visual form is never a constant and fixed pattern but depends, among other things, to a very marked degree on the motor activities of the observer both preceding and during the time of observation. Purdy states further that "motor impulses tend to shift the pattern of sensory excitation in such a way that the foveal impressions are seen at the place in the visual field toward which fovea is impelled

to orientate itself."

Goldstein and Jablonski showed that motor processes not only influence the localization of sensory excitations in the brain, but also can determine whether or not the sensory process is being sharply localized at all. It is thus possible for motor processes to exert direct influence upon the actual distinctness of vision. Rexroad, some years ago, showed that if strong motor patterns are set up in the extrinsics the after image which is certainly partly retinal and partly cortical can be completely suppressed. We must conclude from these and many other similar instances that the weight of evidence points to the fact that there is constant natural rivalry between the sensory and motor systems and that the natural tendency of the motor apparatus is toward equilibrium while the sensory system exerts the opposing influence. The motor system thus can react upon the sensory excitation pattern so as to level out differences which oppose the trend toward equilibrium.

A further consideration must be given to the genetic development of perception. In early childhood, coherence, not disjunction, is the primary state. The child's vision, Claparède pointed out, is syncretic and diffused. The phenomenal world to the child is not an array of discrete elements but rather of vague totalities. Purdy further points out that our primary problem is to explain disjunction, not coherance. William James, thirty years earlier, pointed out that everything coheres that can cohere; and nothing separates except what must. Unless some active influence tears them apart, the parts of visual field always form a coherent unity. When a simultaneous rivalry between oculomotor tendencies is set up, disjunction is the consequence. To see effectively, therefore, one must develop the active skill of arranging conditions which will permit certain processes of the visual field to become salient while others remain groundal. Skill is not only a process of achieving coherence and banishing disjunction, but it is the proper and opportune use of the disjunctive process for the disembedding or segregation of form.

Some of these functions ultimately achieve the status of a semi-permanent structure of the perceptual field, for example, habit relief in stereoscopic vision.

It seems clear from even a casual survey of experimental and theoretical literature on visual form perception, that this is the heart and soul of visual training. It is likewise clear that posture, movements, fixations, phorias, ductions and such things are subsidiary to the ultimate end of single clear shapes. When the orthoptist approaches the task of the reconstruction of vision through training, lens application and what not, he can only proceed on the basis of a clear and thorough analysis and understanding of the visual status quo. There can be no question that skill in seeing can only be developed when the primary functions are first brought to the state of function compatibility.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: V

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One of the most interesting and important things about the effects of training upon the perceptual function lies in the differences which mark the change from the untrained to the trained or skillful status.

From many experiments made in the last decade we have been permitted to observe these changes and to set down some of their characteristics. In this paper I shall report some characteristics of the stages of the perceptual process, and in a subsequent paper some results and suggestions for training which have developed from many experiments.

It is of great importance to keep in mind constantly that the trained perceiver achieves a result which is essentially and radically different, qualitatively and quantitatively from that of the untrained. Further, the change in function due to proper perceptual training is entirely different from the sheer increase in memory content which may result from frequent impression or detailed analytical study.

One of the primary bases of differentiation lies in the course in retention run by the total impression effect. From the moment of impression of any visual pattern there is a constant process of change in the sensory-cerebro-motor residuum left by that impression. If the pattern has been seen piecemeal, i.e. by the successive fixation and examination of separate parts the usual thing found is that when retention is tested by an appropriate method the weaker, less coherent of these drop out or are transformed to fit the stronger aggregates. The whole effect notably moves in the direction of conformity to sets, patterns or schemata of larger scope. These may be recognized as identifiable with such broad considerations as temperament -- the cautious, meticulous and pessimistic perceiver exhibiting a kind of shrinkage and deletion contrasting with the expansive elaboration of the converse type.

For example, a paragraph was read to a third and to a sixth grade class in a small city in a far Western state. Few children had ever seen even a medium-sized city. The paragraph in question described elevators, doormen, park policemen, apartment dwellings, etc. After 1 day, 1 week and 6 weeks the children's reproduction of the story was written as best they could. The change in the pattern to fit the perceiver's own frames of reference was a notable characteristic. The loss of retained fact was large. There can be no question that a primary objective of training is the reorganization of the residual effects of previous experience to make this an immediate and accurate means for the identification or classification of current impressions.

An expert botanist conceptualizes the flowers belonging to a specific class, order, genus, species, etc. He notices instantly a sport or mutant which "fits" the classification in all respects save one, i.e. the specimen has one too few petals. The "memorizer" or content-trained perceiver would, in most cases, likely miss the example completely, generally resorting to perceptual filling or such like to take the place of the lack of accuracy in function.

Perceptual skill is primarily therefore not a matter of refining or extending the pattern of excitation from the sense organ. It is rather a transformation of the whole course of the function in terms of the perceptual-motor-backstroke processes which <u>follow</u> impression. This latter effect extends in time and so produces a still further important difference. The tendency is toward stability, accuracy, speed and the difficult to describe empathic sense of competency and mastery. To learn to trust your eyes, brain and effectors is thus more than just a copybook maxim. Much importance attaches to the conditions and events which both precede and

follow the period of impression. As in the classical reaction-time experiment there are four distinct phases to the process of the perceiving of any set of exposed figures:

(1) The Foreperiod. This is characterized as the period of instruction, set, orientation, understanding of what is demanded in the situation and the assumption of the proper posture, address or attitude for the reception of the stimulus. Dodge has named the series of events at this stage protopraxis, which literally means preparatory or preliminary movement.

There is little need to point out here the great importance of this stage in the process. It is so far-reaching in importance in perceptual experiments by tachistoscopic methods that Knight one time said, "It is as if the show is over before the curtain goes up." What one perceives is so largely determined before the stimulus is presented that not only should great care be exercised in the control of this phase but perhaps also we must regard it as the first and most important objective of all visual perceptual training.

Instruction should be understood in its true and broad scope. If I say to a trainee "You will see a small circular field for a very short time. Fixate the black cross in the red pre-exposure target. Assume an active-search attitude. Be able to describe or draw what you saw following the exposure." Such a verbal instruction must be heard and understood. It must be accepted and willingly acted upon. What goes on with the observer from this moment until the exposure is given can only be inferred from his subsequent performance. One thing however is clear: the observer may make an honest effort to rigorously follow the spirit and letter of the instruction, seeking thereby to discover how to set himself so as to obtain the maximum proficiency in performance, or he may place his own construction upon what is to be done, and how it is to be done projecting himself and his activities "out there" among the figures, forms, words, etc. of the stimulus much as if he were selectively clipping flowers from a garden for a living-room bowl. The proper conduct of the observer and the perfectly synchronized and synergized efforts of observer and experimenter is what makes the experiment or training session a success or a failure. So it is easy to see why we insist that observation is a fine art, a skill, and must be learned through first hand experience. And may I add that the most troublesome and weakest observer to whom I have ever tried to show a tachistoscopic form for reproduction was an alleged artist -- a painter and writer on art subjects. He was simply locked in the fetters of finalistic thinking and no matter what the instruction of the experimenter, he followed only his own, and to him, the better course. That it was unproductive, erratic and not conducive to learning was of no consequence.

Every impression serves to create a set, for better or for worse for the next exposure. If we begin with small numbers of digits, letters or geometric forms and gradually expand the number and reduce the time as we see it to be appropriate we soon realize that, set to see 8 digits, if we give only 7, we may get either 8 in the reproduction or a sharp complaint that there was confusion, blurring, movement of positions, etc. Blame is usually ascribed to the apparatus, to the targets, to the experimenter -- anywhere except to the place it rightfully belongs, namely, to the insult or disruption of the dynamic pattern set by prior exposures.

Skill as an experimenter or trainer means a constant alertness to sense each change the observer shows and to vary the procedure appropriate to the signs he exhibits.

(2) The Impression Period. This is the period of the appearance of the stimulus. It follows a preliminary "Ready" warning about 1 1/2 seconds before the "Now" which is followed another 1 1/2 seconds later by the exposure. This phase terminates usually several seconds after the cessation of the stimulus. Any activity before this time will result in a significant suppression or hampering of the excitatory process. Stimulation, as Verworn pointed out many years ago, is a process of heightening an activity which is set to go or going on at small amplitude. It is excellent advice to an observer to give the impression a full chance. Three to five seconds after the exposure should elapse before beginning the next phase, which is the period of response.

(3) The Period of Response. This may consist of movements of naming, handling, drawing, or implicit, diffused non-localizable motor processes. It is here that the effects of phases 1 and 2 take direction. Quite

often, as emphasized in the preceding paper in this series, the motor transforms the sensory or bends it to a state of congruency.

It is quite important that the perceiver from the first be led to feel and experience the correct consummatory response. The stimulus is the agent for aggregation of phases 1 and 3. This is why short-stroke sketching is, like cheiroscopic drawing, such an effective means of developing correct form perception. It is probably the reason why the oral method of language instruction developed by Professors Monroe and Hendrix has been so successful. I am told that learning the piano is much facilitated by the ear-hand-eye sequence rather than eye-hand-ear.

If an observer sees perfectly a group of digits or other forms and starts his oral reproduction and his voice stumbles or falters we have observed almost invariably that this is a perfect eraser for all that follows. The blocking may occur at the very beginning. From such observations we conclude that the perceptual act is never completed until this third stage in process has been successfully negotiated.

Early in the training, change of mode of response is detrimental. If the responses have been spoken and a shift to writing is made there is a period of readjustment. When skill has reached a higher level of attainment the mode becomes more a matter of indifference.

Pressure and anxiety to make a perfect record may disjoin the motor process. The smooth performance of the expertly trained perceiver is like the highly skilled virtuoso--the response flows ballistically out of nowhere, with great ease and with it comes a feeling of aesthetic gratification and confidence. This is, no doubt, a partial effect of the overlap of phase 3 with 4.

(4) The Period of the Backstroke. In this phase the proprioceptors within the effector apparatus discharge centripetally into the active regions of the conducting structures completing the organic circuits and giving validity and unification to the entire series of events in each of the four phases. As training continues of course foreshortening tends to erase boundaries and it is as if the whole process takes place in the time of conduction and reaction.

The backstroke is important for several reasons. It is the means of providing the maintaining stimuli by which contractile effects can be made to greatly outlast the instigating stimulus. Pain and shock are examples in which the effects may summate, often to the point of disaster. Certain drugs block only the backstroke (scopolamin, for example) so that single volleys and twitches do not become circular and self-maintaining. It has been shown (Guthrie) that when certain muscle groups are curarized conditioned responses cannot be established. The so-called 'substitute' or conditioning stimulus must operate both with its own <u>and</u> the unconditioned or natural response mechanism or no learning could be made to take place.

Similarly the experiments of Shagass are interesting. Berger waves are minute electrical effects picked up from a pattern of electrodes upon the head. This investigator conditioned the alpha rhythm on fist-clenching. He found that the process was reversible--clenching the fist induced alpha rhythm and alpha rhythm produced a noticeable contraction of the fist. When an observer was instructed to image the fist movement, the alpha rhythm was induced.

The backstroke furnishes the only reliable index of the end or consequences of any act of perception or manipulation. It becomes, therefore, the agent for the active reconstruction of subsequent responses to the same stimulus pattern. It may be regarded as the same sort of scientific event seen in gunnery where the method of approximation and correction is used. One shot is over and another under by measured and observed amounts. Then follows a bit of calculation by least squares and the third shot is right. Without such a mechanism it would be difficult to show how, in any protoplasmic organism, ends can and do transform the means to those ends.

Psychological Optics
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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: VI

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The tachistoscopic, or short exposure, method of perceptual training forces the observer to see coherently rather than disjunctively. If we examine the statement critically it contains an apparent paradox. If a light pattern of .003 second duration reaches the eye and this pattern comprises, for example, a seven digit number, such as 3795814, physically if the digits are of 36 point type and are viewed at 16 inches, the region of retinal excitation will lie well within the limits of the anatomical macula (Polyak). The phenomenal macula, or the region within which sharp form of each digit may be seen may be more extensive than the limits of the anatomical macula. We have recently secured experimental evidence that the limits of the phenomenal sharp form-field can be extended by training. To what extent is unknown. But the fact that eccentric regions may have form thresholds lowered from training suggests at once that the change is cortical rather than retinal.

In substantial accord with such reasoning may be cited the facts of the Aubert-Föerster phenomenon, that peripheral acuity may be better for smaller than larger targets; the susceptivity of the perimacular regions to increased resolving power consequent to training; and the observations of Gelb and Goldstein, and others, on the development of pseudofoveae.

Physically, the 7 digits at 3 ms. reach the retinae essentially as a <u>simultaneous</u> exposure since an exposure of such order lies well within the limits of the specious present. The opportunity is therefore present to the observer to see the 7 digits as a simple coherent whole. But, unless he is trained, he never does.

Psychologically all tachistonopic exposures above a certain very low temporal limit are <u>successive</u> exposures. The digits are seen in groups and sub-groups with some at once salient, dominant and pace-setting. (Schwarzbek, Knight.) The number 3795814 may be seen as 37-95-81-4; as 379-581-4; as 379-5814 or in almost any of all possible groupings.

The first term in the perceptual structuring of the retinal excitation fields is the fact of grouping. This process need be regarded as nothing more than the manifestation of the fundamental law that every field composed of segregated "parts" in different positions will tend toward a more stable organization as a figure -- ground structure. The order in which such "parts" are apprehended is unknown but in the main probably follows the temporal order of emergence or disembedding.

Nor do we know the "size" (i.e. fractional groupings within the whole) of the "parts" themselves. (Schwarzbek.) It is quite likely that the time relations among the successively apprehended groups and the intrinsic impression-index of the individual groups are the determining factors. Unity then means not a primary state of the impression but one which is attained by an active process of structuring or patterning. This will always show some dominant regions which behave as figures, with the others playing a secondary groundal rôle.

Because psychologically the <u>present</u> is not a brief point in time but a variable distance, within this specious present a number of <u>successive</u> units will be perceived as unitary sub-groups.

Lumley showed that in serial multiple-choice experiments such sub-groups become larger with extended practice. From such considerations we can begin to see something of the mechanism by which 'larger' perceptual aggregates become phenomenally 'smaller' as a consequence of training or practice-effect.

In quite different experiments Gamble (1916) and Renshaw (1932) showed independently,

that if units, in language type learning, are presented in sufficiently rapid succession, i.e. with little or no opportunity for grouping and re-grouping, no learning takes place even when the number of impressions is very large. Skill in perceiving must be therefore a function which involves a second stage of the re-combination of groups and sub-groups to conform finally to the smooth successive motor process employed to write, draw, or speak the impression pattern. An analogy is the learning or perceiving of a melody comprised of a sequence of discrete tones--or the typist who when in doubt as to the correct spelling of a word seeks verification by writing it.

There are many lines of evidence which point to the essential soundness of such a theoretical approach to the mechanism of perceiving.

Aveling, for example, showed that if he reversed one letter in a series exposed tachistoscopically it interfered with the others. It has been observed many times in our laboratory that in longer exposures any digit which produces an eye-pause in the transit of the eye from left to right across a horizontal row for any reason will have detrimental effects on perception and reproduction. The zero is the worst offender in this respect--a fact which seems to conform to similar observations of Köhler and von Restorff.

Likewise we have shown that digits shown in a clear field are harder to organize and perceive than digits printed upon a microstructured ground. Position of any item in the visual field is more strong and stable if that item has an anchorage in a suitable ground or is seen as a constituent of juxtaposed and compatible other (but not necessarily similar) items which form a sub-group.

It has long been recognized that the act of perceiving runs a course with practice which involves telescoping, foreshortening and simplification. Titchener showed that perceptual activities which early show all the four stages described in our last paper (Vol.4 No.6) finally become direct apprehension. This is the state in which the executant act is set going at once upon the receiving of the impression impact. There has been a complete or partial degrading of the complex series of events which Bartlett has described as "the search for meaning." It becomes less and less necessary for the "stimulus" to be clear, sharp or of long duration. The purely sensory portions of the total function diminish in importance reciprocally with the rise of the emphasis on the motor aspect. If we can imagine a perfectly trained perceiver we see him less and less dependent upon purely sensory differentiating cues to meaning--i.e. to a final satisfactory consummatory response.

Let us take one further step. The repeated adjustment to similar situations must be assumed to leave in some form within the sensory-cerebro-motor mechanisms patterns which become increasingly more and more non-specific. Some writers hold that our fundamental sentiments on rational issues are things of this type; non-specific, non-localized, non-verbalizable attitudes, sets. These kinds of things constitute the perceptual frames of reference, which Knight showed play such a decisive role in the perceptual process.

Skill in perceiving is a reorganization of the cortical-motor consequences which follow excitation. This is often a highly individualized thing and it is unsafe to presume that general procedural rules can be laid down. Schwarzbek showed that after extensive experimentation and analysis of his results no simple and constant relation could be found between (1) the number of digits exposed; (2) the minimal time of exposure; and (3) the mode of perceiving of the subject. Further it was shown that the rate and amount of improvement were not solely dependent on the amount of practice and that the slopes of his curves were the same whether an ascending or descending order of length of number was used in the training.

It should be noted that in these experiments specific number patterns were shown but once to any observer. Hence improvement could only be regarded as a change in the formal process, and never a mere fixation of memorial content. Such change is not a consequent of the adoption of superior method alone. Success is so highly individual a matter that regular and repetitive methods of impression prohibit reorganization by discovery by the perceiver. Gain in speed and accuracy is not

essentially a simple matter of grouping skill. The same grouping processes were observed in exposures below 0.1 second as in much longer number and exposures.

It is safe to say that "associations" never play an important role in perceptual training, except a detrimental one. They are never seen in exposures below 5 seconds. In longer ones the ascription of a number combination to an historical date, for example, is almost certain to hamper and interfere with all that follows it. For instance in the number 729149231-647295, suppose the first group of 3 digits, 729, is seen to be followed by 1492 -- such emphasis is followed immediately by large increases in error in all positions to the right.

Grouping and the course of the process cannot be controlled consciously. Introspective judgments by an observer as to what he can or cannot do, the correctness of his last reproduction of a seen figure all are about equally unreliable.

We should be aware of the fact that digit training aims at the creation of a level of functional proficiency in a mechanism which is non-specific. Proper mastery of the technique of tachistoscopic exposure and reproduction of digits will facilitate the mastery of spelling and reading English words. It likewise will set the stage for the more rapid and stable improvement of other visual perceptual functions.

If TCA is shown, the same letters arranged to spell CAT can be seen farther away and in shorter time (Cattell). Children learn to read English largely by seeing single successive words. They must later learn the tricks of grouping or remain as many do, weak and inefficient readers.

Of interest in this connection was Dr. Schwarzbek's study of the relation of the time required to read aloud a number and the exposure time to memorize it for reproduction, by Salo Finkelstein:

Length of Number (Digits)	Mean Reading Time (Ave. of 10 trials.)	Memorizing Time
N	Sec.	Sec.
9	1.6	.030
12	2.5	.820
15	2.5	1.47
18	3.3	2.40
21	4.0	4.40

Note that at 21 digits the reading time becomes for the first time shorter than the memorizing time. This must mean that below such limit the visual impression is in a formative stage of correlation <u>before</u> the motor coordination is set.

Our paper next month will deal with some further phases of the process. My thanks are here expressed to Drs. W. C. Schwarzbek and Otis D. Knight whose experimental and theoretical contributions to these problems are among the best in the literature.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: VII

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The consequences of acquiring a level of perceptual skill at or beyond the shoulder of the curve of improvement are many and varied. There is an abundance of evidence that there will be found covariantly significant improvement in a number of related visual and non-visual functions. If the training is given on digits, for example, at the far point, the region of the phenomenal macula within which clear forms may be seen is enhanced. This is probably due to the fact that in repeated exposures the locus of fixation changes and certain perimacular regions are utilized which ordinarily would not receive the excitation. Bennett, in our laboratory, exposed 15 letter words to a trained observer for .001 second. These words were unfamiliar. They were double spaced so that at 16 inches the subtend was 12°19'40". To quote "These were enough to demonstrate the possibility that words which extend beyond the macula (anatomical) can be immediately perceived." During the past summer Murray made an extension of this kind of experiment. We arranged exposure materials eccentric to a central fixation target. These were gradually extended to include a larger and larger subtend at the eye. The experiment was carried on for five weeks during which time four of five observers showed significant gains in that they could correctly reproduce numbers and letters correctly which were delivered at and beyond the margins of the limits given by Polzak for the macula. Form disappears completely in my own right eye at 11.5° nasally. At 10° a 36 point letter or number is seen clearly. At 12° there is only a meaningless 'something out there.' Yet, two of Murray's subjects were able to show a high percentage of right reproductions at 24° temporally, and I tested an Army Colonel from Mitchell Field, an expert pilot of the super-fast fighter planes, who reported correctly every 36 point number and letter I showed him at 64° temporal O.D. This is about the limit of the color zones for the average eye (Duke-Elder). These tests were made on a Ferree-Rand perimeter fitted with our mirror fixation and special target holder. A naval commander in California who was for years a football official on the Pacific Coast gave a similar response to a crude test I made on him with numbers cut from a calendar. There is little doubt but pseudo-foveae can be set up by training and necessity widely eccentric to the line of sight.

From our Navy experiences we have seen acuity at far point increased in myopes, with also significant increases in No.19 finding. Coupled with other standard training procedures the tachistoscopic training will be found to be a valuable addition to the procedures available for the functional reconstruction of seeing.

A highly important phase of tachistoscopic training is the procedure I have called counting. By counting I mean the instant and accurate estimate of the number of unit positions in a number. Without this skill the formal process is weak and inaccurate.

Early in our work we discovered that if an observer had been seeing 12 digit numbers and we next showed him an 11 digit number he would frequently reproduce 12 digits. If one additional digit was shown he would again reproduce the number of digits for which he was set by instruction to see.

From such observations we concluded that in the absence of any pre-exposure instruction, a portion of the time of exposure must be devoted to a "counting" appraisal of the size, length or pattern relations of the impression. This comes to be done without awareness, but it seems to be a component skill of the highest importance in the development of high orders of skill in seeing. It is entirely probable that in reading or the perception of digits or conso-

nants, counting becomes eventually integrated with the process of seeing total form. In visual patterns such as a landscape or a face 'counting' probably operates as a first-order type of field structuring in which the spatial positioning of total masses sets the stage for the later and more elaborate types of figure-ground organization. Likewise, it is probable that this function is the 'simple' basis of the discovering of the intrinsic pattern of organization in perception which so greatly facilitates the whole perception-memory sequence. To illustrate, look at this number:

3 8 1 3 1 8 2 3 2 8

When you see that 5 added to the first digit makes 8 (the second digit 8) and that 5 added to the 8 gives 13, the next two digits, and so on -- thus, when we "see" this scheme or 'plot' of organization, the labor and difficulty of perceiving and remembering is greatly reduced.

The term 'plot' was coined by Dr. Otis D. Knight when he was a graduate student in this laboratory. It was his significant work which threw much light on the mechanism of this form of perceptual training. Since his dissertation is as yet unpublished, it seems most appropriate to quote Doctor Knight's own discussion of this point:

"The concept of plot. As a single term to express the unity of a movement-system, tentative or overt, as Washburn conceives it, or of a behavior-circuit as Gestalt theory defines it, or of a skill in representation of stimulus elements occurs in a time-transcending fashion, as described by Renshaw and Bruce, the term plot is proposed. In a plot there may be active, forward-moving sub-plots, totally unrelated in effect unless their participation in the main plot is considered, but compatible when it is. A plot may be given in a telescoped way, just as the plot of a story is present in the title to one who is familiar with the story. It may be imperfect, may lack esthetic (cf. dramatic) unity, coherence, and grace; but with repetitions its felt awkwardness, irrelevancies, and excesses tend to realign themselves or to disappear -- not additively nor subtractively, but in a transformation of the processual whole. It is never a constant and detailed projection-counterpart of a sensory-field pattern; never, on the other hand, out of relation to one. Even in free imagery, environmentally determined postures, responses to gravity, temperature, blood chemistry, self-instruction, and the like, lay down at least broad limitations to the scope and direction of the plot. The sensory field provides and partly sets the stage on which plot runs its course. This may be in simplest and briefest outline, or may be elaborated to the last delicacy of phrase, -- the fundamental plot is the same in either case. Plot is objectively what meaning is phenomenally.

Perception and memory are always only more or less surrogatory. Physically an ink blot on a page is swirling aggregation of myriads of unit charges of electric force in explosive activity. Nothing about the perception of it suggests this. Such a perception is rather a way of doing, a way of adjusting in a world in which ink blots occur; not a direct representation or knowing of the complex physical activity system.

Plot is always subject to refinement, always short of perfect economy of energy. Ultimate adequacy in perception would imply complete quiescence, experiential blankness. Both the image and language are subtended by fluent performance, though not with perfect fluency. Performances already made fluent by learned refinement of plot constitute effective set. In all fluency the element of time becomes spurious, unless time is seen as a qualitative attribute of performance, not as a limiting frame in which acts are run off serially. Fluency means that a behavior-circuit has come to involve its own end from its onset. A fluent performance underlies every experienced whole. If cohesion or homogeneity is the primitive stuff out of which all articulation is derived, its simplicity is imposed by a motor resultant from stimulation. As a simple experimental check on the truth of this statement, let the reader observe the difference in quality in the darkness in a perfectly dark room with eyes open and with eyes shut. It must be supposed that even in the simplest case the performance resultant from a given set of stimulating field conditions is indescribably complex, but is based on posture as a vehicle in which are compounded language, gesture, and the whole array of representative, foreshortened constitutive

responses.

Accordingly, ground may be defined as a particular set of conditions that make up a referential frame. It is organized in a relatively more leveled, totalized, homogeneous way, and includes both excitation and trace factors (set, interest). In this frame plot runs its course in the particular way dictated by the necessity of maintaining its own sharpened, accentuated organization in a functional relationship to concurrent and preceding ground.

The initial lag of the figural experience, reported by all subjects, is in accord with the temporal values assigned to the emergence of figure quality in black areas on white grounds by Wever. From exposures of less than ten milliseconds his subjects were not able to obtain the figure experience. From ten to thirteen milliseconds exposure produced a certain kind of figure experience to which the name simplest was given. Fifteen to twenty milliseconds produced good experience, and twenty-five or more milliseconds were required to produce perfect experience. Each of these kinds of experience has its own peculiar characteristics in shape, localization, depth, and contour. The time values are more congruent with effector-reactions than with changes in electrostatic fields. In that an eight-place number in 36 point type can be correctly reproduced after an exposure of only three milliseconds. How are these two orders of facts to be reconciled? It is clear that the ordinary processes of approximative and corrective eye movements in reading could not take place in the latter; what, then, does happen? For one thing, persistance of retinal excitation which provides a readable image is denied by all subjects. For another, the subject must know that the exposed material is to be numbers, and must know how many digits there will be, and must have had protracted previous practice in memorizing numbers not too long before the attempt is made, although the practice need not be with the extremely short order of exposure times or relatively short numbers involved in what is usually called spanning. Success in the act is not invariable, and the successful act is always characterized by the subject in definitely motor terms; he must set himself in a particular way, he must carry out an undescribed but aggressive activity of some sort before there can be even the beginning of report. If this activity is smooth and precise, if there is no tripping or stumbling, if the launching of the act is auspicious, there may be success; otherwise, never. It is a misstatement to say that an eight-place number is perceived in three milliseconds; there is invariably a delay before the subject begins his report, and, while no quantitative determinations of the extent of this delay have been attempted, there is every reason to believe that it is at least as long as the orders of time suggested by Wever as necessary for the emergence of good or perfect figure. We may conclude, therefore, that if the action-plot for material about to be seen is sufficiently sharpened, ground will be very near figure. Most of the constitutive performance will have already taken place; the bulk of the show will have been acted out before the number is exposed. But this calls for a very high order of skill. Not just anybody can do it. The exposed digits have a value as signals in the super-performance, even when peripherally given, and probably even if the eyes are in motion, that they lack entirely for the novice."

It can be seen, from the above quotation, that skill in 'plotting' is a highly important product of learning in training to perceive. It is almost always self-taught and consequently often badly taught. It is one of the things which suffers first from a relaxation of proper motivation. Introducing an able learner to the concept of plot is often enough to start him on the road to superior achievement.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: VIII

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Perception is essentially a dual process. The two phases are opposite and antagonistic functions. The first has been called aggregation or massing. Since every percept is comprised of a number of widely different components coming from different sense modalities, the combination of all of these tends to be experienced as a single unity as best it can. For example, the taste of lemonade to an untrained observer is a single quality comprised of such factors as temperature, odor, texture, flavor, etc. Yet the blend is tasted as a single simple quality. After training it will be noted that certain of these qualities emerge in a variable temporal order and the pattern may show itself as an aggregate of qualities with widely differing intensities. Aggregation or massing is the process by means of which we see things together. Even in simple shapes, the process is ever present, and the skill with which we do it is of fundamental importance. Spearman, a number of years ago, said "relations furnish the very woof and warp of shapes or whole qualities." (Brit. Jour, of Psychol., 1929, 19, p. 3.) The essence of this process is to see intrinsic relations of appurtenance or belongingness which establishes a basic coherency within the members or 'parts' of any perceptual pattern.

It is very likely that in this function we find the essence of the process of creative imagination or invention. It is the mechanism by means of which the observer designs a tool out of sticks, stones, and string, figuratively, to solve a problem in mechanics otherwise impossible of solution.

It should be pointed out, likewise, that sensitivity to the detection of these relations is enhanced by practice or training and that it is not localizable or subject to direct conscious control. Just as in any form of problem solution, the proper time and space relations for the emergence of the solution cause it to emerge unconsciously. The process is fairly launched on its way when the perceiver discovers identities of forms and functions in the total stimulus which confronts him. In the development of perception in young children it is not uncommon to find this process active almost as soon as the child learns to walk and talk. In other children the delay in the appearance of this ability to see relations may extend to the eighth year or even to puberty. It should be clearly born in mind that part of the structuring which means the emergence of clearly identifiable form has its origin in the interrelations of the various components in the stimulus pattern. For example, some parts may be grouped together because they all have comparable brightness and all consequently contrast with other portions serving as surrounds. But we must also bear in mind that an equally important phase of the process occurs when the afferent volleys from the sense organs give rise to central processes in the brain and nervous system which redintegrate similar types of movements expressed in the original situation. Note that we have deliberately avoided the assumption that the perceptual act is consummated by fusion or blending of the afferent sensory pattern with some more less prominent hysteresis effect left in the fabric of the cortical cells from prior instances of the same sort. The weakness of such argument lies in the fact that if we subscribed to it in this form, we should immediately commit ourselves to the doctrine that the strength and the validity of perception is a direct correlate of the frequency of any single response to the stimulus pattern. The work of Dodge on variability in behavior is sufficient, I believe, to nullify any such argument. The position taken in this paper does not deny the importance of memory traces, nor does it disregard the possibility that the training of the perceiver is always a case in which there comes to be less and less

dependence upon the properties and attributes of the stimulus pattern and more and more derived as the contribution of central mechanisms. This fact has been pointed out repeatedly for example, in the writings of Titchener, who cites the instance of walking through the lawn and wondering how the piece of broken glass got there. On closer scrutiny he saw that the bright refractance was from a piece of whitish limestone. Interpretation often runs far in advance of the physical facts that are given.

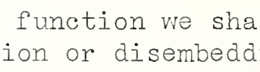
In tachistoscopic training we must constantly be aware of the fact that much of our effort is directed to the business of reorganizing the conventional habits of the observer in grouping and subgrouping. Skill emerges as a consequent of being able to build homogeneity into a perceptual structure which otherwise would be seen as a mere collection of discrete items. The basis of the seen relation which favors coherence and homogeneity is perhaps an expansion of a function present from very early age. From childhood to adulthood we are constantly exercising the counterforce of analysis. What people call attention and concentration is the business of singling out and setting apart features within the total perceptual pattern selected for more intimate scrutiny. It is clear that such habits tend to hamper and interfere with perceptual aggregation. The poor reader, for example, sees words as individual particles of sentences, just as he probably sees each separate brick in the mosaic of a common brick walk as a unit. The pattern of the tile bathroom floor, however, takes on many shapes and arrangements. In some instances it is not difficult to pass from one to another until a dozen distinct forms emerge perceptually within almost as many seconds. Tachistoscopic training, which is primarily devoted to developing this unseen skill of perceptual aggregation should never be lost sight of. Its status can only be derived from the case study and analysis of the observer's successive performance with appropriate materials and the subjecting of these results to careful and thoughtful analysis.

Most of the problems of syntax arise in this manner. For example, look at the following sentence:

John said his teacher was a fool.

If we insert a comma after John and after teacher or if we merely insert a comma after the word said we may immediately transpose subject and object in the sentence. Meaning thus largely derives from grouping. Grouping largely derives from the perceptual and attitudinal habits of the observer. Let it be emphasized that strong and important as we must regard the function of aggregation as a basic skill in learning, to perceive we still must give due and proportional emphasis to the second of these functions which it is the object of this paper to describe.

This second function we shall designate as segregation or disembedding. It should be noticed that by these terms we do not mean the mere selective emphasis referred to above as attending or concentrating on some feature of a total pattern. Segregation or disembedding refers to the active process of reducing virtually all portions of the pattern to the status of a ground which thus permits the figure to emerge as a sharply defined unit. The task of segregation or disembedding is often difficult because it must be accomplished in the face of the forces of aggregation which in some instances are quite strong. It has been pointed out by a number of experimenters that if a figure such as the following is shown for a brief exposure, it is only with difficulty



that we may discover in the central portion of this figure the English capital letter "K." The "K" is effectively masked, hidden, or embedded in the whole pattern. The symetry of the two hexagons, separated by a vertical line, works to keep us from seeing the superstructure which is the English letter. Skill in segregation must also be developed by training. Just as in the opposite process, the mechanism is impossible or difficult to localize and the forces which control it are not open to us for direct control. It is a task for the future in research in this province to devise suitable materials which will give us tested and proven results. At present we must rely upon the fact that we subject the trainee to a sufficient variety of perceptual tasks that he will discover for himself the means of exercising both important functions. Digit groups seem to provide

for this type of training in marked degree. It is entirely possible that any twelve digit number shown to an observer tachistoscopically forces him simultaneously to organize the total impression into its final stable form by the exercising of both of the above described functions. It is easy to conceive how aggregation could operate upon groundal features while at the same time the segregation of the figure goes on apace.

One further fact needs emphasis. As training proceeds there is always a tendency toward simplification or fore-shortening. This process we look upon not as a primary function but as a derivative of the process of aggregation and segregation. As training proceeds we know that the factor, time of exposure, becomes less and less significant. Observers are frequently astonished to find that perceptual functions previously consummated at one-hundredth second can now be done quite easily at one-thousandth second. It is probable that this only means that the relation between intrinsic organization and time has undergone a characteristic change. It is, perhaps, the reason why we have come to place less and less stress upon the time factor.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: IX

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As you read through this series of papers on the general problems of perception, it becomes clear that we are not greatly concerned with the placing of strict categorical limitations upon the meaning of this term. If it is true that to be is to be perceived', it is equally true that the act of perceiving which names, classifies, signifies and orders objects, events and relations for both immediate and subsequent handling is an act which extends beyond the present. We have emphasized previously that the stage is set, the course determined in most instances well in advance, temporally, of the sensory impression patterns which represent things 'out there'. The function of these excitation patterns thus becomes more and more an agent of merely furthering the activities already set to go or in process in low degree at the moment. Verworn pointed out, many years ago, that a stimulus can serve but one function -- i.e. to heighten the rate of oxidation or the activity of a mechanism which has previously been set on its way. Most predictions are things of this order.

The emphasis which should be placed upon the backstroke, the events which follow the manifest consummation of the act, has likewise been made in a previous paper.* From these considerations we must view the perceptual act as a long-section process, truly molar in the sense set forth by Wertheimer and Tolman. And if such position can be held, among other consequences is an immediately recognized difficulty in harmonizing it with such recent theory as that proposed by Professor Hull (Principles of Behavior, '43). The whole trend of experimentally observed fact and of the theory deducible from it seems to me to point in a different direction. It shall be our task in this paper to examine three or four phases of the problem which have some very important bearings in psychological optics.

First, let us look at a concrete, everyday case. A girl of 17 comes in. She is about to graduate from high school. She leads her class. Her general health is good. She wears about 5Δ minus spheres, having "achieved" these by an annual series of steps starting with -0.5 at age 6. She is a high esophoria at both far and near. Pursuit movements jerky, spastic and irregular. Stereopsis, depth and distance discriminations very low and weak. Reading excessively slow and labored. Tachistoscopic thresholds for digits, shapes, words, phrases very high (i.e. weak and inefficient). Yet in face of all this, this intelligent girl by industry and effort made a fine scholastic record. She came to us because she discovered her problem and wanted to do something about it before going on to college next autumn.

Suppose we set about to do what we can for her. What shall we do? We may decide to pursue the philosophy that the way to force her to recreate her visual space world is to control it by altering the relations, sizes, etc. of the stimili "out there." This is about what the man did for her who placed between her and her external world an increasing series of biconcave lenses. Her problem was not only not solved, it was made progressively worse for her.

Suppose now we start upon another track. Let us set it down as axiomatic that we must work with materials, process "in here" and not with the hypothetical stimili "out there." This is not a mere phrase. It is a desposition. We commit ourselves to work in a realm of great complexity. We must work as the photographer with fast panchromatic emulsions by feel, time and temperature, that is we may only observe the <u>effects</u> of the alterations of functions

we induce by training, we cannot watch or measure them directly and immediately. So we begin the often slow and laborious process of replacing mechanisms that are weak and inefficient by others strong and smooth. Do we do this by merely encouraging this girl to go back home and work harder, do more of what she has already been doing with poor results (mechanically at least) for the past eleven years? Never. A golf swing which is basically, mechanically wrong can never be cured by the tinkering, hunch method. The right way is to start all over to build the perfect swing. This can never be done by retaining the old wasteful habit. We must first get rid of it. This is often effectively done by direct and immediate replacement. Do the positive thing as it is to be performed ultimately and do it now and never permit an exception or return to the old habit. Last week I saw a man hit a golf ball as he had never felt one in 20 years after a single hour of instruction by an expert - - a man who is both a fine golfer and a fine teacher. It can be done. But, to fixate this good movement he must work it and practice it until it 'does itself' under any and every circumstance. Visual skills operate the same way. We must realize that if our teeth need attention twice a year, our vision should certainly be checked annually.

I wish there were some way at my command to emphasize sufficiently this axiom: we work with processes, functions, that portion of the world which is of our own active fabrication - - the part we do something about. That something may not be right. It may need to be changed in one way or another. It is the business of psychological optics, the science, to find out how and what; it is the business of orthoptics to bring this proper professional care to those who need it. And how many do.

At this point the skeptic rises to a point of order. He has read the previous papers quite carefully. He "rises to remark:" "all right - - all you are saying is that our job is to build or rebuild what you have called 'frames of reference' - - doesn't your argument merely reduce to that?"

No. It emphatically does not. Let us see why not. Important as are these temporally early parts of the total perceptual act are, (we label them frames of reference, traces, sets, predispositions, sentiments, attitudes, beliefs, etc.). They are not enough by themselves. There must be something more. That something more is the active, vectorial unification of the then and the now phases of the total process. We must have the residual after-effects of training and experience. We must also be skilled and adept in the active structuring of the perceptual field of which these portions serve largely as the ground from which some figure is conatively fabricated. This constitutes the act of perceiving, and at the same moment serves as an instructive set, in the pattern of the delayed response, to alter the subsequent course of similar experiences. Perceiving is thus an active structuring or shaping of a total field which is in large measure already formed before the stimulus reaches the sense organs.

Our 17 year old 'takes' our training better if we arrange to 'have her do something about it.' Her acuity will improve if we instruct her to adjust the viewing tubes, grasp the headrest as if she is steering an airplane, press her silent key to signal the moment of the minimum separable point, etc. It is her performance. She battles her own 'par' from day to day. She learns how with the help and guidance of the professional man or woman who has done this same thing with many others and who knows when to stop her, when to increase the discrimination-difficulty, and so on.

We soon reach a place when we can bring to our aid another tool or weapon. We can begin the rational attack. We want to build stereopsis. We explain many things about the multi-space world of the skin; the space-world of the blind; the simultaneous touch - sight impression; chieroscopic drawing and projection. She works with knowledge. She does, now, much better. Only later on do we take this approach. Too early it may produce negative results.

Now, one more point is deserving of some clarification and of some emphasis. I want to present a brief in behalf of a doctrine which has come to be held in low esteem by many learned people. Some of us think this attitude is wrong and unjustified, and that even the devil deserves his due. I refer to the doctrine of Fomal Discipline - - or, explicitly, to the pro-

blem of the general effects of specific practice.

Mathematics, languages, science, were taught because they were presumed to furnish, in addition to a fund of contextual knowledge and of surrogate skills, a certain kind of learning how to learn. In reaching a level of achievement somewhere beyond the novice stage there would emerge relations which are never learned directly. The plan of the strategy which won a famous battle and a war was said to have been made many years before on the football field at Rugby.

Much of the condemnation of the doctrine of Fomal Discipline arose because the defense was assertion: exercise of hypothetical mental faculties was good for them regardless of the kind or form and the more the better. Certainly I do not wish to argue for such a position. But, let us re-examine the doctrine after translating it into the terms of modern molar conceptions of behavior.

If we train a person tachistoscopically to or beyond the shoulder of his curve of improvement, using digits and a few English words as materials and if we do this by using both a far-point and a near-point method, we find that in addition to certain very specific skills he has also unconsciously acquired certain other skills. His formal skill we know comes later than his ability to perceive and reproduce content. He will tend to see the number of digits for which he is set by instruction to see, self-imposed or otherwise. His digit training will show low correlation with the same processes now engaged in reproducing lists of consonants but high correlation with the structured arrangements of the same letters as they spell English words. His resolution at far point will be increased. His reading rate will be grealy expanded with no loss of comprehension. His general visual perceptual grasp will be surer and quicker.

I have no hesitancy in stating that the formal skill acquired thus indirectly or incidentally is as basically important, or even more important, than the out and out memorial increase from the training. Without the former there is no evidence that achievement can exceed the level of mediocrity in the latter. Such was the case in our 17 year old girl mentioned above. Her reading was piecemeal, fragmentary, discontinuous. She always had to give it an aural second going-over to let her fine intelligence span the handicap imposed by the visual blocks. Small wonder that after a month of training she felt an intellectual rebirth. She felt the sense of visual mastery, certainty, unity - - for the first time. She will now go far. She will master her problem.

The limits of these papers will not permit the citation of all the evidence in support of the principle that the general effects of specific practice are of primary importance. We have seen it repeatedly in language learning (Multiple Codes). I demonstrated it in the case of a manual skill (pursuitmeter) and in tachistoscopic research in the past 12 years. I have seen it again and again more strongly emphasized. The one regret is that its precise qualitative and quantitative description is a task for future research. The ice, however, has been broken. When the bad speller first gains the feeling of confidence and mastery from simple smooth and certain performance he has gone a long, long way to remove an enveloping block which can and does hamper many other functions. The conception of unity in molar behavior demands just that - - and that it is.

Psychological Optics

—BY—
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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: X

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When we train a person to perceive visual forms, we have pointed out in previous papers that one highly important aspect of this procedure is a restructuring of the field. This process is much more complex than first impression gives and therefore calls for greater exposition.

For many years, the problem of perceiving was hampered and held back by the damaging influence of atomistic and elementaristic theory. It was held, for example, that the summation of part processes produced the unitary wholes which are the primary data of perception. It is significant that from 1917 on, when attempts were made to demonstrate such principles experimentally, they met almost universally with failure. The primary question which was certainly not clarified by neurological and physiological studies was this: how can the molecular changes within the central nervous system which are mere potential gradients form the basis for the many different qualitative and quantitative visual patterns seen in ordinary experience? If we can measure and describe the properties of such patterns in the brain, can we predict properties of the external stimuli which instigate them? Eleven years ago, Bartley published a monograph in which he showed that in the absence of external stimulation, conduction patterns were detected with his instruments of precision which differed only in amplitude from those found during the period of active stimulation. The question naturally arose, why do not these processes of lower amplitude yield continuous weak perceptual experience?

One of the key contributions to our better understanding of these problems was proposed by the late Max Wertheimer who proposed the theory of isomorphism. This theory was simple and direct. Wertheimer said, "Let us think of the physiological process not as molecular but as molar phenomena." He argued that if brain processes are molar, then their molar properties will be the same as those of the perceptual processes which they are supposed to underlie.

What is the distinction between the two points of view designated on the one hand molecular as distinguished from the molar? A simple illustration should serve to make this clear. Out of my office window stands a huge tree. The graceful sweep of its branches gives a number of interesting shapes. The all-over picture of the tree as a tree includes the realization that if it were suddenly removed from the landscape, subjects beyond it now hidden from view because of it would immediately take their places in my field of vision. Its apparent size, color, shape, etc., depend not alone upon itself but to a surprising degree upon other items which combine to constitute what we call the landscape.. When we describe the tree as we see it in ordinary experience, the terms of our description are essentially molar. They deal with masses. They arouse thoughts of Mach's statement that in nature the only constancy is the constancy of relation.

Into the office now comes two of my colleagues whose life work lies in two different fields of science. The first asks me, "What are you staring at our of the window?"

I point to the tree and his answer is, "Oh, yes, a lusty specimen of the pin oak family. The leaf of this tree has an amazing absorption spectrum and under high magnification, the mechanism of the opening and closing of the pores in the top and bottom leaf surfaces is one of the wonders of nature. As I look at the tree, I visualize it as a chemical factory of most unbelievable complication. I see within its microscopic and sub-microscopic structures miracles going on which you, a poor

misguided psychologist, know little or nothing about."

Apologizing for my ignorance, I timidly suggest to him that somewhere in the course of his interesting and learned description he has completely lost the tree. When he talks about the cells comprising the parenchyma and the hydraulics of sap transfer in the system of the plant, these products of his analysis have moved him over into the realm of molecular description. His own sense organs at some time or other had to extended by such instruments as the microscope, the spectroscope, and similar devices to give him the properties, attributes, and relations which comprise the bulk of molecular description.

It must be clear that the molar perceiver and the molecular perceiver are both talking about the same thing, only in a relative sense. It would be quite wrong for either to insist, for example, that his view is the basic or fundamental one. Both are two aspects of the same reality. Each in its own way contribute things of high importance.

Our second guest, silent up to this time, is interested in entomology. To him, the tree is a teeming city of bugs, insects, flies, and birds; and he delivers for the both of us a most interesting half hour on the changes in the resident population around the clock of a typical summer's day. He points out that the elm next door to our pin oak is slowly dying from a virus infection, the chemistry of which no one understands. Our biologist friend sees the tree and the landscape from a descriptive point of view which lies somewhere between the two positions previously described.

For all those engaged in perceptual training, it is of high importance to keep constantly in mind that the patterning or structuring of the perceptual field is a complex process in which part of the organization is dependent upon external and part on internal factors.

For example, suppose you move into a new house. The moving van places all your living room furniture in the center of the room. The furniture is new. The ultimate positions and relations of the pieces will give to the room structure and form, unity or disunity. The same rugs, chairs, tables, and pictures, by mere rearrangement, can make the room appear larger or smaller, beautiful or ugly, restful or stimulating depending upon the cleverness and skill of the person who does the arranging. It was a great contribution to the field of perception of Wertheimer when he pointed out that the individual parts are not the primary things. They are not pieces to be combined into an additive whole, but intrinsically from the very first these so-called parts are parts of wholes. In another place, Wertheimer wrote that "simplicity does not refer to the properties of individual parts; simplicity is a property of wholes." It cannot be too strongly emphasized that wholes or unities are the primary bases of organization in perception. We move in the process of perceiving from whole properties downward towards sub-wholes and sub-parts.

It is a question whether wholes or unities are ever perfectly attained except in the ultimate case of the highly trained perceiver. Certainly the achievement of maximal organization within the perceptual field is a skill which only long periods of training can bring to a state of near perfection. Most of us in adulthood have developed the bad habits of disjunction in which the process of aggregation is frequently replaced by the tendency to segregate the whole into salient figural parts. Fortunately, these processes have been subjected to considerable experimental and theoretical study. Within the brief limits of this paper, we may mention only a few of the laws of field organization in perception which have been derived from these studies. Again it should be mentioned that the serious student of tachistoscopic perceptual training may observe the operation of these principles almost daily in his work with digits, English words and sentences, geometric shapes, and the like. If the serious student desires to read further on the pioneer experimental the theoretical work in this field, I suggest the study of three books: Koffka, Principles of Gestalt Psychology, Ellis, A Source Book of Gestalt Psychology, Kohler, Dynamics in Psychology.

One of the simplest principles of field organization is the principle of proximity. If we listen to a series of clicks of uniform intensity and quality, equally

separated in time, we hear these clicks in patterns of two's, three's, or whatnot. The mere fact of togetherness in time or space is sufficient to enforce a kind of grouping which is a consequence of the limitation that our sense organs and motor apparatus are only periodically disposable for perception. The row of uniform dots may be guided the same way into sub-groups because of the operation of this principle. In such a row of dots, if every third one is gray while all the rest are black, then the factor of similarity manifests to force a type of organization which is a consequence of this factor. In a similar fashion, the principles which Wertheimer has described as uniform density, subjective set, direction, and closure may operate separately or collectively to give structure and form to the pattern of impression which reaches the sense organ. Obviously it is important to sharply separate the external and internal factors of field organization. But if we know and understand these principles, we reach a point where we are better able to control the course of the process of perceiving. If we wish a figure to stand out more sharply etched against its ground, we do better by recognizing and utilizing these principles.

Impression patterns may show a type of reorganization which resembles the action of internal forces. When only a part is seen - - the upper part of a face looking over a fence - - we see it often as complete, filling in the remainder. Details may be omitted or changed to fit a plot, plan, or scheme characteristic of the dominant or salient feature of the whole impression.

The antagonism of brightness and color in contrast, and of color and form illustrate the warfare of resolution which goes to shape every impression we receive visually.

Much work remains to be done in this province. Particularly is this true for the realm of visual training. The reconstruction of a patient's fundamental visual habits, therefore, must be regarded as contingent upon a proper assay of where he starts from, what he brings to you when he seeks your professional help.

Training is thus something more than building separate "skills." In the future, orthoptics work will demand an even greater knowledge of these mechanisms and their control than we possibly conceptualize at present.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

PERCEPTION: XI

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We come now to the end of another series of twelve papers. We have tried to sketch an introduction to the fundamental problem of how we perceive our worlds of things and processes. The end of the series of papers is by no means the end of the problem. Logically, we should continue with a whole series dealing with the problems of visual space and its relations to all other phenomenal spaces; time and its extension, and motion. Some time ago, we briefly touched upon the fact that the skin, the most primitive and extensive of our sense organs, furnishes for us the key to our better understanding of why it is that psychologically there are many spaces and that visual space particularly is intimately bound up with those genetically earlier.

Recently, I had occasion to read some things relative to certain procedures for the training of persons with anomalous space perception. Here the emphasis was wholly and solely upon corresponding retinal points. A disparity of but a few seconds, we are told, is sufficient to preclude the possibility if clear, simple, and direct discriminations of distance. The picture drawn by the writer was one of rigid physical geometric specificity. I have found it difficult to reconcile the observations made in the laboratory which run counter to such type of construction. I have found it even more difficult to justify the serious consideration of so narrow a view of so manifold a problem as that of the visual third dimension.

In these papers, we have tried to indicate the growing weight of evidence in support of the motor theory. We have tried to show that the complex pattern of impression which reaches the sense organ is the starting point of an elaborate system of transformations, enhancements, and suppressions which take us to the point of identification and classification of the seen thing. From this point on in retention, we know likewise that the after effects of the impression are never static. They pass through a series of progressive changes, usually toward simplification, loss of detail, a return, in a word, to the simple primary state of masses, totalities, and consonant and conformable unities - - consonant and conformable to the lattices or frames of reference which are constituted of our immediate and long section interests. The heart and the essence of this whole process is movement. No phase of it can be regarded as stationary. This contrast may be simply and clearly brought out by the relative appearances of a strange city which you have laboriously explored, first on foot on a very warm day and after several hours of weary, slow excursion. You then fly in an airplane over the same locus. How different in the second case are the size and distance relations. How different even is the sense of personel relation to the scene.

The stages in the process of perceiving have been worked out many times in a number of careful experiments. We have tried to re-emphasize the importance of the fact that the impression itself is always set in a matrix of memorial, attitudinal, and similar sets which decisively determine its course. From the moment of impression and even well in advance of it the stage is set for the search for meaning.

But meaning is a type of adjustment, a type of manipulation or handling. It is always couched in terms of what is good for us to do or what the thing will do to us. We name or classify objects, first, in terms of the usages characteristic of them, and from this simple beginning we may pass through several sta es of elaboration or simplification until we achieve some satisfactory stopping point which may be, and often times is, far from the terminus of the process. We train ourselves as

scholars to avoid the pitfall of being satisfied too early. We try to keep our minds open and our eyes looking forward to the ultimate extensions which these processes may bring to us. Meaning can only exist in relation to a certain species of total adjustment to a disturbed equilibrium state. Life which is sessile and perfectly complacent would ultimately end in a gradual and progressive restriction of those processes which give us our proper orientation in the world. It must be clear to every thinking person that Bishop Berkeley was right as rain when he asserted as early as 1709 that vision alone is of itself incapable of furnishing us the means for our fundamental discriminations of size, space, position, movement - - in a word, of the very foundation of those things which comprise the realities of our visual worlds. It is the clear recognition of this fact that led Von Hornbostel to emphasize so strongly the fact which biological considerations fit so perfectly: namely, the principle of the unity of the senses.

I feel that this line of thinking should be continually emphasized because of its significant bearing on the problems and methods of visual training. The reorganization of the perceptual habits of an individual should always be done with the doctor holding clearly in mind what it is he is seeking to accomplish. Often he must proceed as if he were synthesizing the whole by a combination of subparts. If we watch a squad of carpenters, masons, plumbers, etc. begin to build a house, the unorganized piles of timbers, bricks, and mortar seem to be the essential units of construction. But if we watch even a short while we notice that the boss man unrolls a sheath of blueprints and that every stick of wood and every cement block takes its place according to the master plan. I know of no one courageous enough to start the construction of a dwelling with nothing to guide him but the forlorn hope that if he merely starts nailing things together he will come out right in the end.

The difference between the kind of conception of the process of perceiving, learning, and remembering we have attempted to show in these papers and the view widely held which derives from such notions as we referred to above relating to visual space is a difference of basic importance. This can be seen if we consider another phase of the problem of perceiving as yet untouched in our description. Here I refer to the problems of imperception. It is customary to call these things illusions. Most of us are familiar with scores of types of conventional visual illusions. How can we account for the apparent convergence to a point of the steel rails stretching away from us into the distance? How shall we account for the apparent difference in the size of two identical circles surrounded by larger and smaller circles? The conventional sense has usually been that such false interpretations arise from the deception of the sense organs themselves and that this is effected by an induced change of posture or an apparent bending of the lines or masses to produce the anomalous appearance. No less than two dozen alleged explanations have been offered, for example, to account for the apparent differences in length of the Muller-Lyer figure - - two parallel lines, the ends of which are bounded by V angles pointing in opposite directions. Implied within every conventional notion of the nature of an illusion was the conflict between "reality" of objects and the appearance of these same objects. In every consideration of the problem of illusions with which I am familiar there was implied the fact that the illusory object is to be regarded as if it existed entirely independent of any supporting framework in perception. Suppose we look at any simple illusory experience from the point of view outlined previously in these papers. Suppose we postulate that by the very nature of the mechanism it is utterly impossible for the steel rails beyond a certain point to do anything other than to converge, that is, to approximate positions which are below the threshold of resolution. Suppose further we assume that I may have a focal or central figural process for set in a ground which is not coordinate with the schemata build up by previous training to specific signification the resulting interpretations will be at variance with the normal expectations and hence will be classed as erroneous. But this error classification is the act of a neutral observer. Actually the visual convergence of the rails is the perceptual reality. The fact that is exists at variance with the physical reality is simply a limitation forced upon us by the fact that no organism has as yet evolved sets of eyes, brains,

and effectors capable of operating in strict conformity between the phenomenal and physical worlds of reality. Any pattern of figure ground structuring is capable only of producing that significance which the perceiver's present organization will permit. In this sense no illusion ever exists. Further, if we assume the existence of the traditional concept of the illusion, and push it far enough, we arrive at a nihilistic position which forces us to assert that every instance of perception is illusory. The antidote for processes classed as illusion, hallucination, obsession, and the like, is the further rational extension of the process so that a proper appraisal of all the determinants of the perceptual act may be considered. This becomes one of the salient arguments in support of the proposal that the classification of human experiences into such catagories as perception, learning, and memory rests upon a very insecure foundation. They all run a course in time. Any immediate or cross section description or analysis is, therefore, bound to be partial and fragmentary and open to the deficiencies incident to such partial treatment. It was the clear recognition of facts of this sort which must have lead psychologists like Theodore Ribot and Alfred Binet to the realization that perceiving is the first term in the beginning of reasoning. When we clearly become aware of what any problem in which confronts us or, in other words, when we clearly perceive all the relations of the problematic situation, the most expedient solution emerges as the next and often the only succeeding step. Thought and reasoning are thus only long section elaborations of the simple beginnings found in the act of perceiving. This is why, for example, in tachistoscopic training, the process of the perceptual manipulation of subgroups to aggregrate them into larger or wider unities pulls in its train such things as an immediate and forceful expansion of reading skill.

We should give more attention to the field organization of a percept. The non-seen portions of the visual field, i.e. the grounds - - fore, mid, and back, within which figure is seen to emerge can and do strongly influence the strength and coherence of the figural unity. What damage is done when we weaken the supporting frameworks which assist in our achievement of stable shapes? Movement or change or instability of position is one thing. This is manifested in the well-known phenomenon of autokinetic streaming. A single point source floats about in space and takes, for each observer, a characteristic direction and course. A student in our laboratory, Mr. W. B. Lemmon, trained in relaxation, found that when he observed a point source prone on his back as he became well relaxed the point became stationary and he perceived himself to float about in space slowly with respect to the point source. The change in posture must have yielded a radical alteration of the ground and hence a consequent radical change in the character and locus of the figure experience. If this is true, then it is small wonder that postural changes can and do change the findings of refractive measurements, as our three groups of optometrists working in the laboratory this summer have been able to demonstrate.

The control and reorganization of field structuring in perception <u>is</u> an important matter. The future will, I predict, see it as a field of increased study and research.

Later it is hoped we may return to a detailed examination of the visual perception of space, time, and motion. Meanwhile a series of papers on another closely related province will begin next month.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

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The beginning of this fifth series of papers should be prefaced by an overall look at those which have gone before. At the very beginning, an attempt was made to show that psychological optics has a distinctive role to play in any and every type of professional eye care. The first four volumes in this series have attempted to show that the functions of seeing are not rigid and fixed alone by physical and chemical determinants but that functional operations themselves are capable of instituting developmental changes which tend toward stablization and subsequent transformation of the functions in later operation.

The problem of the relations of function and structure has been a center of much debate and controversy. This has arisen largely because of an inadequate and incomplete understanding of the precise nature of the problem and from the laxities of language. In all scientific work it is of the utmost importance to realize clearly and to define the nature, limits, and setting of the problem and to use descriptive terminology free from the ambiguities which prevent people from speaking the same language when they discuss such problems. Paul Weiss has recently said, "Ill-defined, vaguely defined, or undefined terms are a scientific curse; they make scientific language oracular instead of unequivocal, hazy instead of clear, and degrade all scientific work described in such language."

As a simple example, a paragraph or two earler we used the term development. What is the precise meaning of the term development? How does it differ from growth? How is it related to the type of changes in living organisms subsumed under such terms as training, learning, and memory? Take your notebook and on a separate page write the most complete and comprehensive definition of development as a scientific term you can, without consulting other sources. Now lay this aside and consult the most recent edition of the best dictionary of the English language at your disposal. Write this definition beneath your own and wait a few months until the first half dozen of these papers have laid down a proper foundation for the understanding of the meaning of development as a scientific term, and you will have an unforgettable experience of the truth of our previous assertion and that of Professor Weiss: in science, the English language is an instrument of precision. We must learn to use it as such.

Our objective in this series of papers will be to go back to the very beginning and do now what we should have done then; namely, lay down a stable foundation for the concepts and procedures now followed in practice and in the course of development. A few moments ago we used the words science and scientific. What do they mean? Of course, everyone knows what science is. Science has been defined as what the scientist works at. But such a definition merely defines by restating the problem. In order to find out what the scientist works at, we must first find the scientist. Where shall we go? What do they look like? How do they differ from ordinary men? Are they like a cartoonist's concept - - a man with a pointed black beard --prince-nez on a shoe string - - a man persistently absent minded and outside of his laboratory essentially a moron in all practical matters of life? Obviously this is stuff and nonsense. There is only one science and it is definable only in terms of a particular group of operational methods and principles by means of which we may describe the things and processes which occur in nature. Anyone becomes a scientist merely by setting up an appropriate set of postulates, subscribing whole heartedly to this set of principles, and consistently and persistently adhering rigorously to them. Rigorous adherence to the set of postulates determines both the kinds of problems one shall attack and the manner and means of one's attempt to resolve them.

Because of our human limitations of time,

interests, and other practical considerations, we introduce artificial divisions of labor and pluralize science because of academic or industrial convenience or necessity; but there is no real foundation for such a procedure. One division of science differs from another simply in the fact that while all divisions start from a common set of postulates, our specialized interest soon forces us to set up additional working principles which do not belong to other fields. The only way, for example, we can distinguish the subject matter problems and methods of physiology from those of psychology is by this means.

All sciences begin, for example, with the fundamental postulate that the "real" world of objects and events exists. This means immediately that if we accept this postulate, we lay the ghost once and for all of controversy and argument over the idealistic question as to whether the fountain pen writing these words only exists as idea if the plastic and metal materials which comprise it are swirling masses of atoms and if I know its existence only mediately through my tactual and kinesthetic sense organs. Then it is inevitable that we always grapple with the problem of how human beings can know anything and the most perplexing problem of the nature of knowledge itself. Immanuel Kant, in his critique of pure reason, discussed this question at great length and with great astuteness. Most well trained scientists will readily grant that the consideration of such problems by the philosopher and the metaphysician is highly necessary and worth while in any system of culture. But the scientist also insists that this problem be left to the specialist within whose province it rightfully falls. There is no law which forbids the scientist from an occasional sortie into this domain. The clearer he realizes what he is about, the more he saves himself from the inevitable grief which always follows as a consequent of loose thinking. In theory, at least, if we were all infinitely competent, we could solve all our problems by the method which the philosopher calls reflection. This is a species of talking to ourselves. It is a linguistic and rational method done in the arm chair. But the scientist argues that he must take the position that because of our limitations, we must go a step farther than this. We must contrive other superior means for the solution of our problems.

We reach a point where it is no longer possible safely to set up a series of axioms and deduce rationally from those the manner in which things operate in nature. We must set up the inductive experiment and the differentiating experiment by means of which we may avoid the pitfalls of logic. We learn very early in the laboratory that the beautifully simple relation which seems to carry the answer to a perplexing problem is deceptive in the extreme and not to be trusted.

A consequence of the foregoing is that we must postulate that the material world of objects and events exists to some amount or to some degree and is therefore susceptible to quantitative measurement and description. As soon as we begin to measure and to describe in the precise universal language of mathematics, we begin to discover those essential relations which are the heart of our science, because it is doubtful if science can do more than merely say that when this happens, that will happen.

Things would be simple and easy for us if the quantitative description we always render were as smooth and easy as the above paragraph might seem to indicate. But such is not the case. Let us think of a single simple instance. Let us take, for example, the problem of visual contrast. Everyone knows what contrast effects are. If I place a small square of gray paper in the center of a larger square of black paper and in the identical small square of gray in the center of a larger square of white and cover them with a piece of tissue paper and describe the appearance of the two identical small squares, one appears very dark; the other, very light. We measure the brightness of the figures and their surrounds and express these as a simple mathematical ratio and we assert complacently that we have measured the contrast effect. The whole process seems precise, secure, scientific. If we stop right here at this first elementary stage, there are no questions to trouble us and we may feel somewhat smug and complacent in our great knowledge gained by experiment. But suppose we decide not to stop. We go on, varying the conditions. We change the sizes, shapes, wave length compositions of the light, boundaries, viewing distances, stage of adaptation of the eye, degree of train-

ing of the observer, etc., and now what happens? From the simple equation set up in the course of our first observations, we must now write a series of equations of great complexity. Because, for example, we soon discover we always add another dimension, time, to our descriptive accounts. And when we do this, we must describe the so-called contrast effect as it runs its longitudinal course in time. Also, as facts multiply and as understanding deepens, we find that the simple word contrast, which everybody understands perfectly has reaches which extend far beyond the limits of our present knowledge. Where it ends or where the final law can be written lies, certainly, in the field of the unknown. The problem of contrast is a research one. The definition of the word must be expanded and qualified. The original simplicity was a false simplicity. Only the little men remain content with the first simple statement and answer to the problem.

Psychological Optics differs radically from physiological optics in one aspect of the process of observing. When we write our postulates in this province, we must set it down as one of our axioms that in the realm of visual experience, we must grant and recognize the principle of emergents. In the so-called physical sciences the addition of two positive numbers always produces another positive number greater than either of the additive components. But in psychology we must add that this is but a single case. Now and then we meet instances in which the addition of two positives may produce a null state. The net effect of addition may be a qualitative or quantitative reduction in the final outcome. The mixture of two lights may produce an effect brighter than the sum of the two physical intensities. The mixture of two colors may produce an achromatic color devoid of hue. Many such illustrations could be cited. These things mean essentially that we must recognize and take stock of the fact that in experience, the contribution of the perceiver is an important term in whatever descriptive equation we may seek to write.

In the last few years, I, as an outsider, have watched the development of the practices of certain optometrists change quite radically. I have seen the basic concepts of seeing expand and take on new forms and practices. I have seen new instruments and new procedures introduced into the offices and clinics for the reconstruction of the visual world of experience brought in by the patient. I am now seeing every month new developments in progress along these lines. Some of them will be permanent. As time passes, they will remain and become written into standard visual diagnostic and training procedures. Others will be found wanting and will be abandoned because this is the way of scientific development. Of one thing I am sure; that in the minds of a large number of men and women, this concept which is basic and fundamental in psychological optics will play and is playing an important role - - more important than ever before in the history of the scientific attack upon the problems of vision. It shall be one of the objectives of this series of papers to show clearly and unambiguously why it is impossible to measure and describe visual processes in isolation. We shall try to lay down a foundation in your thinking which will permit us to see the exact position occupied by the acts of photoreception in the daily stream of molar experiences of the ordinary individual.

There is no question that the growth and development of visual training procedures gives rise to a certain amount of controversy and misunderstanding. Books like Mr. Huxley's Art of Seeing, the Bates method, and the dozen odd cults whose slogan is "Throw your glasses away" represent an extreme position which always finds adherents who hope for the best but who frequently find that the actual achievement falls far short of such an ideal as is set forth for them. A recent full-page advertisement in a national weekly magazine points out conversely that glasses alone can never correct a visual problem. Yet, there are many who subscribe to the glasses alone doctrine. A third group maintains that glasses and training together constitute the professional tools by means of which the skillful, well-trained, and understanding professional man can bring to bear on a visual problem the most potent weapons which science has developed in the modern day for the attainment of the objective of giving to the individual clear, comfortable, and effective single vision at near and at far. It is no doubt true that here again we are confronted by a further misunderstanding similar to the one pointed out earlier in this paper; namely, that the dual division into

two things, namely, glasses versus training, should be abandoned and will be abandoned as soon as a more perfect understanding of the functional relations of these tools is clearly appreciated.

Training is a protean term. It is a generalization which covers a multitude of specific things. It shall be one of the primary objectives of this series of papers to set forth those basic and fundamental principles which must serve as the foundation ground work upon which all principles and practices must be based.

We shall begin in our next paper with an inquiry into the properties and attributes of the simplest protoplasmic structures found in living cells. We shall attempt to trace the manner by which individualization in organisms is achieved. We shall try to give meaning to such terms as individualities in organisms, gradients, axial patterns, dominance and isolation, and the development and differentiation of the primary mechanisms. In this work we shall draw upon the contributions of a dozen or more scholars who, in the last quarter century have done more to give us a solid foundation for theory and practice than perhaps is to be found in the entire previous history.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

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In the history of biology the problem of the relations of nature and nurture is a very old one. How much of the compliment of acts which constitute the behavior of a living organism can be attributed to inherited structure and how much to the influence of use or training has been the object of much controversy since the earliest times. Actually the problem can be stated quite simply: What is the relation between form and function?

Form or structure is a term used to characterize the shapes, sizes and geographical distribution of constituent parts or organisms which comprise the body of the individual. Looked at from the standpoint of morphology the form or structure of an organism is regarded as more or less static or fixed. This apparent stability carries on throughout the life span of the individual organism and maintains its identity in the mass although less observable structural changes are in process all the time.

From the standpoint of taxonomy and ecology, structure has to be regarded from a somewhat different point of view. We must regard it as a more fluid, flexible and dynamic concept. Structure itself is interwoven with function because it soon becomes impossible to retain the strict morphological classification. The work of a single organ or tissue and even its size and relation to other organs and tissues becomes recognized as something other than an independent unit which is self-contained and more or less self-maintained. Individuality in an organism enforces organic unity and continuity which demands the harmonious cooperation of a wide array of parts, all devoted to the business of furthering the successful adjustment of the organism to the demands of its surroundings. This is the idea which Cannon has called homeostasis.

Function must be broadly conceived as the basic set of forms which energy takes in the never ending process of its collection, storage, dissipation and reconversion which comprise the electrochemical basis from which life itself originates. If we look closely and critically at the two concepts of structure and function, we arrive at a position which inclines to view them as two aspects of a single reality. Let us look briefly in the history of the doctrines which have been developed from the studies of this problem. Until the ten year period between 1830 and 1840, it had been observed that in certain plants there was a mechanism for the rotation of sap and before 1830 the cell meant nothing more than a wall surrounding a cavity. Schleiden and Schwann in 1838 observed the cell contents but regarded this as of relatively slight importance.

In 1846, Von Mohl noted a similar substance in plant cells and called it schleim or protoplasma, the latter term having been used shortly before by Purkinje in a somewhat different sense. In this same year Nageli and Payen recognized the importance of protoplasm as the vehicle of the vital activity of the cell, and Braun in 1850 pointed out that swarm spores, which are cells, consist of naked protoplasm. In 1850, Payen and Cohn concluded that the sarcode of animal and the protoplasma of plant tissues are essentially similar substances. The work of Schultze in 1861 is especially important in that it firmly established the protoplasm doctrine, namely, that the units of organization are masses of protoplasm and that this substance is in general similar in all living organisms, both plants and animals.

During the next thirty years there was an intensive and extensive development of this truth. Of particular interest was the theory of Butschli which he advanced in 1892. This was the alveolar or emulsion theory. Protoplasmic structure according to him was an extremely fine emulsion of minute droplets not greater than one micron in diameter. He supported his theory by making artificial emulsions with soaps and oils which showed amoeboid movement and other striking resem-

blances to living protoplasm. One able biological historian asserted "it would be difficult to over estimate the value both practical and theoretical of the protoplasm doctrine for its establishment has not only led to knowledge by which the conditions of life have been materially improved, but has also been an important factor in assisting man to a modern, rational outlook on organic nature in which he has learned to include himself. It is not too much to say that the identification of protoplasm as the material substratum of life processes was one of the most significant events of the 19th century."

The discovery of the cell and the formulation of the protoplasm doctrine naturally led to the concept that the cell should be regarded as the ultimate unit of structure and also of function in living organisms. In the cell, it was claimed, resided the cause of nutrition and growth. It is interesting to note that even at this time there were as many scientists to be found on the other side of the fence. These men held to a theory which was the exact opposite of the cell theory. This was called the organismal theory. They held that the organism as a whole was the primary agent of organization. Their view was quite clearly expressed by the botanist, de Bary, who said, "plants build cells, not cells plants."

Today we are hardly more than a half century from these two radically different points of view. The controversy is still acute over many phases of the problem. In genetics, for example, the major trend of thinking is to localize within specific minute structures the chemical agents which carry the developmental predetermination of physical characteristics, proneness to certain diseases, length of life span, color blindness, and I know one eminent biologist who told me a few years ago that he was convinced that the vicious habit of nail-biting was a hereditary unit characteristic!

Opposed to this view we may quote other eminent scientists. Let us quote from Verlaine and from Holt: "No 'potential' characteristic ever is 'already contained' in anything; and the notion of potentiality wherever used is a mark of finalistic thinking. The contents of the germ cell are not potential characteristics (traits or talents) at all, whether bodily or mental; they are <u>actually proteins</u> and other substances, and to call these substances potential this or that is to flout the truth. They are no innate characteristics."

"Those persons who imagine that they are dealing with potential albinism cyclopea or lethal factors or with a phobia or with instinct or mathematical endowment or ability will in the end have to give place to more observant investigators who can recognize a carbohydrate or an amino acid when they see one."

In the fertilized egg growth is not a mere process of unfolding from within. The egg does not grow or even continue to live unless it is steadily assisted by proper conditions of external warmth, moisture and the presence of important nutritive substances. The exchange of these substances between the growing cell or aggregate of cells and its environment as well as its stimulation, irritability and reactance are matters of the selective permeability of its membrane; of the destruction and restoration of equilibrium between the cell and its <u>constant</u> and <u>correct</u> surroundings. Its entire career depends as much upon where it lives, what cells are its neighbors even as upon its own internal chemical organization. It is a striking fact that up to a certain level of growth and division a cell can take on an entirely new set of properties such as shape, function or rate of metabolism as it lives in the range of influence of powerful chemical agents produced and disseminated in gradients from other cells. It is from the brilliant researches in the field of experimental embryology in particular in recent years that we have been forced to revise our thinking about the concept of individuality in organisms.

Protoplasm is made up of proteins, fats, salts, water, carbohydrates and other compounds but is not merely a mixture of these. It is an intricately organized system and only by virtue of this fact does it serve as the material substratum for those peculiarly orderly activities characterizing the organism. That is synthetic metabolism, irritability, reproductive and adaptive response. Protoplasm must always be thought of as a system in dynamic equilibrium. That is, it continually maintains itself through a

balance of constructive and destructive processes. From the chemical point of view, protoplasm is regarded as a colloidal emulsion. A colloid is a substance in a sufficiently divided or dispersed state. Colloidal particles are particles in which at least one dimension is a minimum usually of the order of about one micron. Bubbles, drops, and films are colloidal structures so regarded because in each of these at least one dimension is small. The dispersed substance in some other material is known as the internal phase; the enveloping medium is called the external phase or medium of dispersion. Liquids, solids, and gases may form emulsion in any set of relations. That is, we may have a liquid in a liquid, a gas in a liquid, a gas in a gas, a solid in a liquid or any other combination of these states. When the cook makes mayonnaise dressing, she mixes oil and vinegar. The oil and vinegar will not mix except in the presence of an emulsifying agent, in this case, egg. The egg beaten with the oil and vinegar forms an interfacial film and this is the third phase of the emulsion system. Upon this depends largely the character of the emulsion. For example, if sodium or potassium oleate is used in an oil water system the result is an emulsion of oil in water; whereas, if calcium or magnesium oleate is used it brings about an emulsion of water in oil. The oil-water and the water-oil emulsions may have radically different properties. By using both sodium and calcium salts and varying their ratio the important change known as phase reversal may be secured at will in either direction.. At a certain critical ratio there is a very delicate balance between the two conditions.

In a system in highly unstable equilibrium such as that found in the retinal cones the phenomenon of phase reversal which may be induced by chemical, electrical, or thermal means provides us with a mechanism for the understanding of how important changes in the functional properties of such a system can take place almost instantaneously.

There is one other important property of colloids which needs to be kept in mind. The colloidal structure of protoplasm requires high surface area so that the highly mobile parts of the system can bear great electrical charges and can provide the basic means of providing viscosity, surface tension, high electrical resistance as well as to regulate the rate of adsorption, semi-permeability or selective permeability in the environs of the cell. Colloidal systems with separate mobile particles are called <u>sols</u> and those of semi-solid consistency are called <u>gels</u>. These terms are not sharply defined and all possible intermediate conditions exist. Whenever a change from the gel to sol state is induced, this is called <u>peptization</u>. Whenever the reverse change from the sol to gel is induced, this is called <u>pectization</u>. In a number of cases these processes are reversible - - in others not. For example, when egg albumin is coagulated by heat, it is impossible to return the gel to a sol by any known means.

A living cell is thus an intricate system in a constant state of disruption and reorganization, yet finely balanced to provide for its unitary response in adapting to the demands of its environs. When a stimulus, that is an aggregate of energy, impinges on it at some point it immediately sets up a local region of high activity at this point in contrast to the low regions of activity at the opposite extreme of the cell. Thus the first beginnings of a gradient of reactance are established and the active end of the cell begins to dominate the pattern.

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A living cell, such as amoeba proteus, is an intricate chemical system. The colloidal emulsions which constitute its protoplasm are so organized and balanced that changes in the physical surrounds are accompanied or followed by changes within the cell. The mutual interaction of cell and surrounds constitutes behavior. Behavior, in the strict sense, goes on all the time. Even the resting state is merely a lowered state of activity. And response to stimulation is a return to, or a restoration of, an equilibrium state which has been disrupted by the energy impact called the stimulus. From this point of view a living organism responds with, and never to, a stimulus.

The word stimulus is difficult to define precisely. One reason for this is that the reacting organism itself is always a prominent and important factor in the end reaction. Let us look at this process a bit further.

At any instant a cell, such as amoeba proteus, is observed in an aqueous medium. The surface of the cell, the plasma membrane, is a compact and orderly arrangement of molecules which forms the surface of separation between the organism and its surrounds. When ionized particles collect or aggregate at one limited region of the surface this is called adsorption. When this happens there is an immediate local change in electrical polarization in the adsorption area, differentiating it from adjacent areas in a potential gradient.

Accompanying the local electrical change at the surface is a change in viscosity, and in the selective or semi-permeability of the plasma membrane. Some, but not all water soluble materials may now be permitted to pass the 'membrane' into the cell where they may be oxidized or form new compounds or emulsions.

Stimulation of the surface with any energy impact has other important mechanical consequences. An exterior-interior pressure gradient is set up and usually the stimulated surface bulges or pushes forward as a pseudopod in the direction of the stimulated region. This process is one of the most important and interesting events in nature. It is practically the basis of life itself.

Note that in the single celled animal the 'skin' or surface of separation performs all the useful functions of sense organs and of motor organs. One cannot make the distinction of sensory and motor, because at this stage all is motor.

Upon stimulation of any point in the cell surface this region becomes highly active in proportion to adjacent and more remote regions. A polar gradient is being formed, sloping from the region of highest activity to the lowest. A pattern of axial symmetry is formed. The high-activity end is dominant and the whole cell becomes organized through activity toward the cephalo-caudad (head-tail) structure. The 'head' is that region or locus of the organism which sets the pace and form of the first steps leading to more stable organic form.

Suppose that conditions are not as simple as those outlined above. Suppose that simultaneously with the above events gradients of temperature, pressure, light, etc., are brought into the animal's surrounds. We now get more and more complex patterns of gradients within gradients. As these become differently disposed in space the organic pattern of course takes what shape it can as a resultant of the summation of these forces. The movements, form, rate of growth, development and differentiation, reproduction or rejuvenation thus are contingent upon the basic and fundamental concept of reactance in protoplasm. It is for reasons such as these that some of us believe that insufficient emphasis has heretofore been placed upon the broad concept of the primacy of movement and an altogether too great stress upon the "sensory."

If an axiate pattern becomes stable, e.g., as an hysteresis effect in protoplasm, the whole subsequent behavior and form of the organism will be altered in conformity. C. M. Child, for example, has pointed out that the nervous system develops out of the "excitation-transmission relation, which in

its simplest form originates from non-specific differences in physiological condition at different levels of a physiological gradient." And that the "physiological gradient originates as a protoplasmic reaction to local or differential action of an external factor, that, physiologically speaking the nervous system itself originates in protoplasmic behavior." (Child, C. M., Physiol. Foundations of Behavior, 110-111.)

There are abundant evidences of the role served by the dominant region as a pacesetter. That is the dominant region controls or determines the rate of activities lying more remote in the metabolic or in the conduction gradient. In the heart a region near the sinus end of the organ normally controls the beating rate. If this region is inhibited by anaesthesia or by cold or if it is removed, an adjoining region takes over and if this in turn is blocked, the functional control may be moved back farther and farther toward the lower end of the gradient.

Similar pacemakers are found at the upper end of the stomach, small intestine and colon; at the upper end of the ureter. Subordinate regions can take on the pacesetting function, in whole or in part. It is readily conceivable therefore that simultaneous and antagonistic regions of dominance may, therefore, diminish or decisively interfere with the smooth and total function of any single organ or of a whole anatomical segment. In vision this concept is of great importance.

If an environment furnishes a sufficiently constant control of orientation of the axiate pattern, say within an electrostatic field, so that a polar pattern is once established, then the head end becomes organically set and differentiation as to size, increased sensitivity to certain classes of energy, structural differences, etc., begins. Dominance is thus a first step towards the achievement of organic unity and continuity. And it must be clear that the question of the true relations of form and function are, thereby, made less clear. Form seems to become more truly an episode in function and not a predeterminer of function. And likewise as form emerges it brings in its wake an enforced reduction of and specification of function. This trend may be seen not only in the process of individuation in organisms but is also clearly shown in the development and differentiation of behavioral forms. Mass action, described for example, by Coghill in amblystoma and by Minkowski in the human foetus, is primary and from this early state the subsequent specific habit patterns are differentiated. In perception, field structuring follows a strikingly similar course. The primary stat is mass, ground, undifferentiation and greater plasticity. Figure and specific for is a later and subsequent achievement, nonetheless firmly anchored in the original matr

One beautiful thing about this kind of thinking is that it gives us a more or less simple, direct and understandable mechanism of organization in organic nature. We need seek no mystic deus ex machinâ. The ordering factor is not some hypothetical gene possessed of Alladin-like powers to shape the course of differentiation. It is a demonstrable and to a rather surprising degree controllable region of dominance. And this is set up, not by some capricious and opportunistic 'unfolding from within' but by the active interplay of forces which aggregate on the two sides of the plasma membrane.

Further let us imagine a 'hungry' amoeba in a water environment. He is equidistant at the apex of an equilateral triangle from two food particles, one a large and one a small one. We watch him through a low-power microscope. We observe many pseudopodia extend in the direction of the smaller food particle, and slow, gradual movement toward it until it is surrounded and 'eaten.

There are two ways we may put in words what we have seen happen. (1) We may say "The animal chose the smaller particle. He loves little bits more than big bits,---." We tell the story. (2) Or, "Adsorption, lowering the surface tension, increased internal pressure, etc., establish high potential region of dominance in direction of smaller (to us!) particle." The animal tells the story. Since we do not know the conditions of choice (and love is better felt than defined) it is safer and more in accord with sound science to follow the second of these ways.

Finally - in the early stages of organismic patterning by the formation of regions of dominance, there goes hand in hand with this process the isolation of parts. This shall be the topic for our January discussion.

Psychological Optics

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Last month we looked, too briefly, at the concepts of mass action, of axial pattern, and of dominance in the setting up of gradients of metabolism, etc., as the mechanism for the building of organic form. This month we shall consider isolation as a similar mechanism of formal structuring, and then we shall pass to the problems of growth, development, differentiation and de-differentiation. These are fundamental concepts.

Why should we discuss these things in a series of short papers on psychological optics? Are they not purely biological problems?

One of the 'reasons' for writing this series at this time is: to present a basis for the understanding of perceiving, learning, habit-forming, remembering, etc.; to show that field organization, the achievements of visual space, visual form, size and distance, etc., are strikingly similar instances to the developmental processes which are always active in living protoplasmic structures. Since training is the means whereby we can reform and restructure the perceptual process of seeing, the better we understand its mechanism and its phases, the more satisfactory will be the controls we may devise and use. It is postulational to say that any training procedure must conform to the patterning of active, dynamic, structure-function relations in living organisms.

Let us not be deceived, either, in assuming that the bearing of the brilliant researches in cytology and embryology are widely accepted as a basis for learning and training or even the belief that training is a province worthy of the effort. A senior about to graduate as an optometrist and a practicing ophthalmologist both within the same recent week in answer to my questions both replied that a phoria is a fixed entity and cannot be changed by any known means. If this is true, my question still stands: What is a phoria? How does one originate? How do you measure and define the state, process or entity?

The answers I got from these two gentlemen did not satisfy me. These answers could not be made to conform to the lines of thinking I have received from my training. Of course their contention is that my own views are merely my own and not necessarily the true ones. To this there can be no argument. The test, and the only test I know, of any theory is an operational one. Can it be made to work? Can you reconstruct the motor or effector patterns in such a way that such restructuring of the field will force the reorganization of the so-called sensory portion of the total process? And if you do it properly will it be transitory, fragile and variable or will it stick?

Also last week a recently retired Commander in the Navy came to my laboratory. This officer two years ago spent eight weeks in the Recognition School learning to see the shapes of ships, planes, etc., at far point. Then he wore:

- 1.50 - 2.50 x 180
- 3.00 - 1.25 x 10

At the end of eight weeks of nothing but far point tachistoscopic training and just before he went to sea, a 21 point visual analysis gave him these new lenses:

- 1.25 - 2.00 x 180
- 1.75 - 1.75 x 180

Last week through these lenses his binocular acuity at far was 20/15. A recheck showed not only no loss in a year and a half with no practice (this officer did no identification work) but a clear indication that a proper training program could unquestionably still further improve his total effective seeing. The officer is now in this fifty-ninth year. Look at the left eye. A study of both analytical examinations in this case is interesting, and hundreds of such examples could be assembled to show that an argument in behalf of the functional possibilities for the reconstruction of seeing is not without factual and verifiable objective evidence.

Any kind of finalistic thinking is bad. We

seek only the truth and hope only that students of how we see will cast up accounts on both points of view and after the evidence is in, make a decision.

When a region becomes dominant as one level of a gradient or physiological axis, it also becomes independent of other lower lying regions. If the difference becomes great enough, physical isolation may be observed. If a short piece of a flatworm is isolated from any level of the body and is explanted it may transform completely into an apical structure or head, other parts of such secondary system being completely absent. If an earthworm is cut in two the anterior portion heals more quickly and shows less restoration change than the posterior.

Physical isolation is usually followed by significant behavior changes. If the isolation is extensive enough the parts either die, or if they live they tend to develop either into new individuals or to become more like the head or anterior portions of the original individual. Parts isolated lose their characteristics as parts and tend to approximate the condition of a whole new individual. The less highly developed and differentiated the more this is true. Size and rate of growth are factors in isolation, bringing certain parts beyond the control of the dominant region. In plants decrease in dominance by plucking buds leads to increased budding. Whatever decreases dominance thereby places an active upsurge upon posterior regions of the gradient to change behavior and form in the apical direction. This fact is not without significance in visual field structuring. Does macular vision dominate and establish a gradient toward peripheral isolation? If so it is reasonable that in case such 'domination' should lead to a weakening of the phenomenal ground, this would conduce at once to a species of independency of figure, rendering it less stable, less strongly positioned and hence subject to alteration of form consequent to change of position. Other similar analogies are at once producable in the visual field. The Schumann effect, i.e., an experimentally produced monocular diplopia, and the ϕ phenomenon in which a single point may split and move in <u>two</u> directions at once, e.g., to the base points of an equilateral triangle, are cases in point. In these instances it appears that 'strong' regions, i.e., regions of high potential or activity, may not only dominate lesser regions but may tend to reduce their spatial separations, or to consolidate them and simplify them. At any rate it is certain that a little reflection shows many parallel between the 'simple' organization within the simplest protoplasms and the far more complex patterns in such functions of the higher vertebrates as object, form and space vision.

Blocks, that is chemical, electrical, thermal or mechanical obstructions, may also become the means of the isolation of subordinate parts. Several investigators have shown that cold influences dominance and subordination in plant tissues by an interference with the normal transmission of excitation rather than the transport of nutrient substances.

This leads to another way in which isolation may be established. If a subordinate region is subjected to prolonged and repeated stimulation it may develop into a region of secondary dominance and thereby achieve as much of relative independence as local conditions will permit. The two-headed flatworm, which can be produced at will by this means or some combination of the several means of establishing multiple regions of dominance, two-headed calves or foetuses, twins and the rebranching of a growing plant are cases in point. From our point of view this is an important phase of the whole problem. Repetition of excitation may serve to so alter the relative independence of a region that its total functions can be transformed. It is likewise conceivable that the direction of change can be reversible. Thus decrement or increment of a function can be brought about by the agency of changes in adjacent or relatively remote regions. Again returning to our field of primary interest, we can appreciate that a change in one part of a visual pattern can restructure and transform the functions of another. A change in far point acuity can lessen an excessive esophoria at near, if the 'field' theory is sound. And I suspect that many of you who will read these lines have repeatedly seen just that sort of thing happen clinically "again and again and again."

In 1923 Newman showed that in the armadillo there are normally four embryos. This quadruple comes from a single fertile egg. Newman showed that there is a quiescent period during gestation, with a consequent reduction in dominance. He argued that

this sets the stage for a number of radial 'heads' usually four. So far as I have followed this literature the evidence is still strongly circumstantial in behalf of Newman's view, but nonetheless it is entirely plausible and consistent with the weight of evidence in studies of developmental organization of the type we have been considering.

From the foregoing it is clear that such concepts offer us also a means of understanding one way in which limits to growth can be set. While there may have been races of giants at one time in our history, our diet, sleep, and activity plan in our present civilization may set definite limits as to height, weight, speed of reaction, etc., through the necessity for a not too great gradient of relation between dominant and subordinate regions.

Human infants are at birth well on the way to some phases of formal structuring. In other phases the infant must wait for locomotion to develop. For if he remains sessile many of his functions will remain in lower subordination. It is highly probable that the visual world he learns to create for himself is a highly integral part of his wider unifying body organization. Mental life is so very largely muscular life!

Psychological Optics

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DEVELOPMENT

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In the biological realm organic form in its various phases originates from a single cell or egg. As the single cell grows it reaches or approximates a limit beyond which it must divide and rejuvenate itself or die. This limit is set by the relation of surface area to the volume of the cell. The cell contents increases as the cube and the surface as the square. As the cell increases in size it eventually reaches a point where the surface or plasma membrane is not longer capable of supplying or passing sufficient oxygen and water soluble foodstuffs. Cell division or reproduction is a means of restoring a balance of the surface-volume ratio. Reproduction or rejuvenation may thus be regarded as an episode in growth. But what is growth? How is it related to development, differentiation and de-differentiation in the process of establishing and maintaining organic form? Is there a basic similarity between these processes and the development of functional forms which we call learning, perceiving and remembering?

Before we consider these problems definitively we must first state as clearly as we can the meaning of, and the differences between, the concepts of growth and development. Paul Weiss* has shown that organic life can be studied either as a process occuring in a limited cross section or as a longitudinal section of time. Most biological and psychological functions are phasic and intermittent--respiration, digestion, work, sleep, metabolism.

The ebb and flow of these functions, important in their own right, are yet modulations upon the longer section wave of what Cannon called homeostasis - a perduring organic unity, changing slowly into new patterns of formal structure. Two characteristics mark the developmental or long-section change and differentiate it from the growth, or cross-section phase: (1) its course is forward to a progressively 'better' or 'higher' stage, "never reversing its trend and never returning us to an earlier stage;" (2) its rate varies inversely with age. Developmental changes are slow, progressive, non-reversing. Physiological changes are 'fast,' periodic and repetitive. In embryonic life development rate is high; function low. Development is antecedent to function, generally, but it must not be implied that development is forward-looking and sets the stage for later functional operations. There are many instances of developmental events which lead to no useful functional end. Weiss holds that "if an effect passes without leaving a trace, it is physiological; if it leaves a permanent residue in the organism, it is developmental." And a little farther on he says that "no vital processes are in themselves either specifically developmental or specifically physiological.... developmental and functional processes are essentially of the same making." This authority finally concludes that, for him, the single trustworthy criterion of development is progressiveness. "Developmental changes are cumulative and progressive; they produce new structures, new shapes, new configurations, new proportions, new relations, rather than periodically repeating old ones as is typical of physiological processes."

Later I shall hope to show, that in psychological optics at least, we must make a further extension of the meaning of the term development. We must broaden it to include those important instances in which developmental progress is occasioned by a recession to a simpler level with a consequent expansion of performance capacity both quantitatively and qualitatively and an important ancillary effect in freeing the organism for still wider conquests. In the development of perception, for example, the transition from the stage of the search for meaning to that of direct apprehension is a case in point. There seems no escape from the recognition as a fact of the doctrine of emergents: that wholes are always something more than aggregates of parts: that when we add two simple com-

*Weiss, Paul, Principles Of Development, Holt, N.Y., 1939.

ponents we may get, as in acoustics, something like the mass of sum and difference tones, unpredictable in experience, no matter how ably the physicist describes the matrix frequencies nor the anatomist the structure of the ear and brain.

In the history of the life sciences there has long been controversy over the problem of nature versus nurture, or of Preformism versus Epigenesis. For the advocates of preformism, every shape, function and structure is present in the fertile egg. Development consists in converting latent into overt and manifest parts, always without the appearance of new emergent properties. In its extreme form the doctrine is a pure biological atomism. The organism as a unity is achieved by the aggregation or addition independent unit 'parts'. An organ is a particular collocation of separate, independent cells. An act is a concatenation of simple, independent, unit movements, such as tropisms, instincts or reflexes.

There was a time not many years ago when this doctrine, coupled with a wrong interpretation of Mendelian heredity, settled almost all of our problems. A child, if he or she was wise in selecting his parents had nothing to worry about. If Billy flunked his algebra and incurred the wrath of his music teacher, the way out for Bill was easy--he simply failed to "inherit" enough of the two magic and mystical "talents," "traits," or "faculties" labelled mathematical ability and musical ability, and the fault clearly belonged to his parents. Parents appease their consciences in the same way. For biologically a son and his father are really half-brothers, chips from the same old block of germ plasm. Bill's "parents are thus an amazing array of different types and varieties of people. Each generation is about thirty years. The following figures will show that in 8 generations, about 240 years, Bill is a product of 510 parents, 255 pairs.

Calendar Years	1940	1910	1880	1850	1820	1790	1760	1730
Generations	1	2	3	4	5	6	7	8
Number of Parents	2	4	8	16	32	64	128	256
Cumulative Sum	2	6	14	30	62	126	254	510

There is no denying that the basic stock is important in giving Bill a stable and educable neuromuscular system, nor that this long line of parents may have set some very definite limits to what Bill can do or be. But there are weighty arguments also for the Epigenetic position. It is perhaps unfortunate that the two ways of regarding the problem of development have been set over against each other as antagonistic and incompatible. Weiss, in the book cited previously, has pointed out that our attitude toward this problem should be a "neither-nor" rather than an "either-or" one. We should examine the factual evidence and from it formulate the best point of view which present knowledge will permit. "After all, much of our scientific progress consists not so much of solving problems as of setting wrong problems right."

The advocates of Epigenesis hold that organisms develop from rather crude, non-differentiated materials. Structural organization develops, not as a process of unfolding of preformed parts inherent in the egg, but are progressively differentiated and individualized as a consequence of the continual exchange of energy between the growing and developing organism and its surrounds. Speeman and others have pointed out that 'organizers', i.e., dominant and pace-setting regions conduce to formal patterning and that the whole system develops as a finely balanced and coordinated unity. An organism regarded as a system of systems thus has no independent 'parts', for parts are really classifications made by an external observer. Strangely this theory of the primary role of the whole, unitary organism is as old as the view that organisms are merely aggregates or hierarchial arrangements of cells, or other unitary building blocks. Organic systems, however, tend to maintain themselves following conditions of disruption of equilibrium which would be fatal to an aggregation in which there is no agent to maintain internal coherence. Parts, organs or segments of organisms are not functionally self-determinative but the amount, rate and limits of their behaviors is set by the constant action of restraining and enhancing forces developed within the organic system.

This principle is of fundamental importance throughout nature. It is worthy of much thoughtful study. The late Max Wertheimer,

and more recently W. Köhler and K. Koffka, between 1910 and 1912 clearly recognized the importance in psychology of this process of organization 'from above' as contrasted with the antomistic theory that construction proceeds 'from below'.

The forces of integration are something even more fundamental than the manifest and obvious mechanisms of coordination and correlation--namely, the central nervous sytem. Many of the striated or voluntary muscles are well developed in advance of any reception of the sole plates of motor nerves. In fact, Speidel showed that the effector creates a region toward which the proliferation of the growing tip of the nerve fibril approaches in the same general way that the tip and leaves of a plant turn into the light. There is no mysterious deus ex machina in an heliotropism. Energy, which takes on form through positional dispersion, goes on where it can and must go--in a potential gradient.

This line of thinking merits much more extended discussion that either space or the writer's competency can give it here. When now we think of seeing and the anatomical eye and all its distance receptor connections developed so early to so late a stage of perfection: and when functional proficiency comes on so late; develops so slowly and often weakly and inefficiently. (Think of the form perception of untrained adults!) You must realize that, for example, it is meaningless to talk of Esophoria in, of, and by itself. Any change in the field which is seeing will induce changes in the total configuration of function. What is field? This is another fundamental concept of modern science. We shall make it the topic of a following paper.

Psychological Optics
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FIELDS

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As I look to the west out of my office window, I see a panorama of trees, buildings, streets, cars, paths and students hurrying to and from classes in an ever changing pattern. Some portions of the visual field are more stable and fixed; others are transitory. When the late afternoon sun is low and orange light is on the green patina of the copper roofs and when the cold murky gray softens boundaries, the scene "looks" quite different. The objects comprising the scene at any moment have clearly defined boundaries; they have position, size, shape, color, and appurtenance. That is, they 'belong' to this particular 'scene', this locale. There is relation, plan of organization, structure within the field. Walks criss-cross through the Oval joining the buildings which house Archeology, Law, Commerce, Economics. A turn of the head and there are the buildings of Metallurgy, Mechanics, Chemistry and Engineering. These names are the designations of groups or sub-groups within the 'field'. And at once it becomes apparent that the visual field is more than something visual. Part, certainly, of the structure of the field which enables me to see together, as a unit sub-group. Portions of this total field are the residual behavior patterns which extend back over years of daily contacts of many sorts.

The first-time visitor who views this same scene does not and cannot see the same scene I do. The bleak walls of that old building over there are really partly transparent as I view it, for it was there that old Professor Blank did such brilliant and important work and young Joe Doaks made the discovery which has since earned him millions and has had such world-wide consequences. If "Stone walls do not a prison make, Nor iron bars a cage" ---- then this is but a recognition of the fact that the patterning of the visual field is something which is largely shaped by agencies which are in reality non-visual.

Even for the British scientist who sat here an hour ago, the view of the scene is an organized field, even though he was unaware of the fact that the nearness, similarity of shape, brightness, color, etc of 'parts' of the field were at work to group or structure it. If his eyes converged and paused upon the stone pillars of one building, he then must have 'seen' the front of another, some twenty-four degrees to thirty degrees eccentric to it, and hence blurred into the unnoticed role of a part of the enveloping ground which served as the stage-setting for the pillared figure of Page Hall. Let us therefore, realize clearly that much of the interplay of forces which fabricate the scene we see, is not directly experienced. And memory adds another 'dimension' to the sensory-cerebro-motor processes of the present.

Purdy has shown that whenever the nasal and temporal retinas are simultaneously excited by two portions of the visual field 'out there', a tension posture is produced by the co-acting antagonistic extrinsics; and the motor pattern may exert a singificant transforming influence upon the purely retinal or sensory activities. The retinal fields, projected to the brain, may be regarded as constantly shifting mosaics of potentials. And the ultimate forms they may take are most certainly contingent upon many factors which are non-nervous. The total body posture, for example, must enforce upon the visual field a ground instrumental in shaping the course, the size, position and interrelations existent and operative within that field. Thus we must realize that the organized or structured field is not a mere setting together of independent parts, or sub-groups. Activities in one part of a field influence activities in other parts. The amount and direction of such influence will depend upon the attributes or properties of each in relation to the other. Specific examples have been cited in previous papers. We need only to point out here that in vision, the concept

of a field is that of an active, constructive on-going process, and that we must take care now to give ample thought to the problems which arise when we deal with seeing from this point of view, for in future years it is almost certain that the revision of practices will follow in this direction. Köhler wrote that "a theory of perception must be a field theory." It might well be added that a theory of seeing must be a field theory. But more about this later.

In biology the field concept has appeared as a natural and inescapable consequent of the many studies of the achievement, through growth and development, of organic form. It is interesting to note that the term 'field' is not found in Professor Child's "Physiological Foundations of Behavior." (1924, Holt, New York), whereas in "Patterns and Problems of Development" (1941. Chicago University Press), it is given a prominent place. It occupies about a fourth of Paul Weiss' "Principles of Development," (1939, Holt, New York).

Let us look at the 'field' as it is used in biology. When the egg divides and redivides, the cells soon become numerous and arrange themselves in a three layers hollow ball-like blastula. The embryonic ectoderm, mesoderm and entoderm are the outer, mid and inner layers of cells. Each of these as it developes and differentiates lays down the beginnings of subsequent tissues and organs. Within the ectoderm, the cells are interchangeable in the blastular stage. If a region which would develop into a part of the brain and one which would become belly skin, are transplanted (Spemann, 1921) the cells "comply with the formative tendencies of their new surroundings," and except for a difference in pigmentation it is barely possible to recognize the transplant from adjacent tissues after healing. Such experiments prove that the cells have no original intrinsic 'fate' or plan and that they must have been acted upon by some external agent of organization which gave direction to their growth and development in harmony with the new surrounds. 'Field,' thus may mean the first simple polar organization of the cell in which a heal-tail metabolic gradient is established; or it may mean the later formation of sub-regional fields, such as a limb-bud.

Just as in the above instances of transplants from the same layer, Mangold in 1923 showed that cells at the pre-gastrula stage can be moved from one germ layer to another --- ectoderm to mesoderm or visa versa, with the same results. As we may well imagine not all properties of the cells are thus 'free'. Size of nucleus, pigmentation and a certain pattern of individual or distinctive biochemical form remain relatively unchanged, even though the cells may take on new forms and functions in the new surrounds.

The field influence shows itself very aptly in the control of the size and rate relations in the formation of joints; and a still more striking case is the development of the long bones. Ossification proceeds from three points or 'centers' -- at each end and in the middle. Between these 'active' regions lie the cartilage structures. As the bone elongates, there is often seen a sudden 'freezing' of the region, probably induced by a hormone produced in some remote structure, and ossification of the cartileges proceeds at once to stop further lengthening of the bones. Such chemical 'fields' are common and well known. The lactation of the mammariae is induced by a substance from the egg-follicle of the ovary. Modern endocrinology is replete with examples of this type. The body as a whole is correlated and coordinated into a smooth working unity because of the fact that the total physiological field organization sets up regions which are functional 'parts' of other wider systems, and these in turn are part and parcel of still larger groups. The direction of the unifying influence is "from above."

The view of tradition is of course, the converse of this: The antomistic parts are built up 'from below'; complex structures are formed by the addition of simple elements. But the weight of evidence is all against such a view. Habits were once regarded as chains of simple reflexes, built up 'from below.' We know today this is not true. The completely learned skilled movement is a transformation of a tension movement, in which antagonistic muscles are constantly acting, into a ballistic movement in which there is no brake-like action. The muscle contraction throws the member in a quick contraction into a percussion stroke. The member swings through free and easy, and approximation and correction is effect-

ed by the sensory appraisal of the direction and consequences of the act.

It must be pointed out, in fact, that a biological or psychological 'field' is a real thing, even though you cannot see a 'field' under the microscope. To some misguided souls, the concept of a field is dismissed as a mystical or unreal agent of organization; a verabal means of solving the difficult problems of unity and individuality in organism. But this is a defeatist point of view and no scholar who will weight the evidence can escape the conviction that the introduction of the field concept is a forward step of the first order of importance. Of course, we are new to it and there are many things for research to do before we can specify the laws of field structuring. But this is a hopeful and glowing prospect. Next month we shall have more to say about the development of organic form and the striking similarity it bears to our own interests in the field of vision.

Psychological Optics

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Fields, at any moment, are dispersions or distributions of energy in space forming a pattern or structure. The essential feature of such patterning is the set of relations which emerge from the fact that the dispersion of regions in space and time differing in area, potential, PH, etc., influence not only each other, but also importantly set up certain controls over other intermediate regions. Sub-regions may be formed so as to represent objects or aggregates of objects bounded and 'separated' from adjacent regions which serve as the surround or support to stabilize this 'object.' Redistribution of energy can occur suddenly and can bring with it a striking change in pattern and in our phenomenal awareness of objects and relations. Examples are many of the so-called illusions of reversible perspective: The radical change in the appearance of the objects in a room as the level of illumination is lowered to a sufficient degree. The books and lamp on a table may merge into something seen as the stooped figure of an old man; illustrations could be multiplied. But then all show quite clearly that our visual field is an internal-external relation of highly unstable order; that 'reality' which we ascribe to what is out there may be more a matter of the contribution of the <u>inner</u> than the <u>outer</u> portions of the field. In states of strong emotion, in prolonged anxiety or high tension, the warping and distortion of what is 'seen' has long been clearly recognized. Here the observer 'reads in' interpretations not justified by the realities given by the total stimulus relation as viewed by another free from the lattice set in the field by the persisting pressures which shape the field.

Some of our field patterns are transitory and quickly changing; others may be more or less stabilized and conventionalized. Paul Weiss defines a <u>field</u> as "the condition to which a living system owes its typical organization and its specific activities." He lists 6 properties of fields which, with some paraphrasing, I quote:

(1) Field activity is an outgrowth of the activity of the physical mechanisms of the body and their interaction.

(2) A field is a unity and not a mosaic.

(3) Fields tend to maintain themselves. The stable equilibrium is a field-pattern.

(4) Field structures vary in 3 dimensions of space and are often multipolar, which means that their effects may differ in opposite senses along the same polar axis.

(5) Fields may change in size without altering relative proportions.

(6) Splitting and fusion of fields may occur with accompanying changes of influence depending upon spatial and temporal relations of the final total pattern.

To these I may add that:

(7) Fields have a fourth dimension--time--in which regular and systematic changes take place.

(8) Active energy change is a basic character of any field. Grouping produces emergent effects conforming to long-section temporal field structures. Language, memorial functions of symbolism and other perceptual elaborations are the agents for maintaining the plot or plan of organization.

(9) In psychological optics, stimulation and response are both agents of field organization, which in turn determines the amount, rate, and limits of visual functions. The field structure is the primary thing.

We shall return, later, to this question of

the basic properties of fields, particularly as it applies to our own special interests in vision. It is my belief that no development in visual science has been more important. Let us look about at another aspect of the problem.

Field theory--and the highly practical bearings it has in many important activities--has developed almost simultaneously in several provinces of science. In psychology its place has grown to first-order importance. In biology it has wrought large changes in thinking and gives promise of even greater future developments. Even in mathematics it has put in appearance and here, where it is called group theory, it is regarded as one of the most important of modern developments. For example, it is recognized that many algebraic equations of the fourth degree and higher are insoluble by ordinary methods. Group theory applied to them makes them comparatively easy (for the trained mathematician!) to solve. What is the nature of this thing?

It may seem the very height of presumption for one who is not trained in mathematics to attempt any kind of explanation. So with proper humility--we shall try. It is frequently true that when 1 of anything is added to 1 other of the same kind of thing, the sum may be greater or less than two. The mere presence of two things in space and time may produce effects unpredictable, no matter how much we may know about either or both as unities. Two points of light is a uniform black visual field set up the beginnings of a structure in which neither point behaves as it would were it alone. Two-ness therefore is a problem, and we are certainly not clear as to its reaches. If you are inclined to regard such questions as 'academic' and 'ivory tower' enterprises, let me but suggest that some fourteen of the twenty-one phases of the analytical eye examination involve stereoscopic vision. You talk quite freely about fusion, often as if you really understand at least a part of the meaning of this word. But 'fusion' is simply our same old problem rearing its deceptive head. Is the third spatial dimension, with fourth time dimension, an emergent added property of two-ness when the two single views "seek to join" another superior (or inferior?) group? Someday research will answer questions of this type. It is enough for us to realize that 'simple' addition is far from simple; that there are many ways in which things can combine; and finally that ultimate aggregate of things may still contain the possibilitie for the existence of sub-groups capable of recombination to comprise new wholes. And when this occurs, new properties and attributes may be expected.

In a similar way we must see that since to multiply is but another way of adding the same cautions must apply here. If x = 5 and y = 2, then xy = 10. If this is true, then yx should likewise equal ten. Whether it does or not again depends upon the nature composition and aggregation of the two and the five. As soon as mathematics discovered it could group things in a number of ways and could treat groups and differences between groups in a more effective computational way, it immediately found in such methods new ways to solve old, insoluble problems. I mention this instance here only to illustrate the fact that group theory in mathematics is another instance of field theory--the same general concept which the great Faraday early recognized in physics.

Let us look now at some aspects of field concepts in psychological optics. Almost every visual "stimulus" is a patternor constellation of energy-densities arranged within some sort of boundaries. If light and dark masses are in moderate nearness one to the other, the change called apparent brightness or contrast effect may be noted. The receptors respond to this and similar kinds of relations. They are just as "real" as are the atomistic patches of light and dark. As soon as light from these patches reaches a retina the brightness gradient sets up a tension pattern. Purdy and others have shown that from this point on the motor or effector component in the developing field structure can and frequently does completely transform the sensory. If the reader entertains serious doubts as to the reality of the influence of the simple fact that the size, shape, position, and brightness of a seen shape depends as much or more upon where and when such shape is impressed upon an existant visual field structure as upon its own intrinsic properties, I can only urge the careful reading of the recent literature.

When the retina has finished its work of compensatory transformation of the so-called stimulus pattern, the enhanced and suppressed remainder is passed on to the brain, there to undergo still further remarkable reshaping in a field of forces which the brilliant

work of Kohler and his students is opening up to us.

But this brain field is a sub-group within the still wider framework of the active (even during sleep!) effector apparatus of the body. One fact alone is sufficient to emphasize the basic importance of motor theory: When muscle tonus is reduced to a minimum in enough of the musclature, there is no consciousness. There are at least three dozen men and women who, last summer, saw in our laboratory and were convinced that visual patterns and skills in the dorsal and ventral total body postures are two quite different things. What kind of mechanism, for example, could leave near and far acuity unmolested and at the same time radically upset phorias, ductions, stereo-thresholds, and, in size-constance judgments pull the distant targets closer and make them bigger? Why have we seen, again and again, this winter the expansion of the true form-fields to 4 to 6 times the original areas from tachistoscopic training using only horizontal patterns of digits which produce as much proportional extension in the vertical as in the horizontal retinas? Only as we examine these things in the light of the field concept are we able to aggregate them.

In moments of leisure I have tried to construct an imaginary visual model of how we see any simple common object - say the blue-green vase of flowers, leaves, etc., on the white mantel of our living room. To do this with any small success I must detach myself as observer and sit on the ridge of the roof - first having either refabricated my home in transparent plastics or given myself a new kind of penetrating vision.

Down there in the room everything is transparent. It is all enlarged so that the streaming of ions are as easily visible as snowflakes. The fellow down there sees and names the vase of flowers. I up here strive to fabricate the whole structural act of seeing a thing. The roots of the skill to see the shape and place of the vase go back to that fellow's infancy. Many years of habit have set the space-time lattice in which the shape is seen. Language--naming--wields its potent force. That fellow's brain is the meeting place for the resolution of a tapestry of forces--up from the past, here in the present, back from the object. Mephistopheles sits down beside me to enjoy the spectacle. "The fool thinks he sees the vase" is his only comment. He must diabolically realize that comparatively little is seen with the eye if all the facts are taken into account. The energy-pattern there in that fellow's brain --see how much of it comes from all the other 'parts' of his body! His eyes furnish something like the melody of a single violin set in the grandeur of the full symphony orchestra.

It is difficult in the extreme to picture one's self in the sanest and soberest of moments the majestic grandeur of a mechanism as remarkable as that involved in seeing any common object. My own crude approximations have not been satisfactory. It has been fun trying, and perhaps not without some useful consequences.

Next month I shall attempt a summary of some recent important research and we shall see how beautifully it fits the field concept.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

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One of the most helpful things we can do, if we wish to form some kind of clear understanding of the field-concept, is to abandon the division of perceptual experiences into three parts or phases; the sensory, the cerebral, and the motor.

It goes without saying that no controversy with physiology and neurology need be engaged in at this point. We can readily admit whatever evidence they may propose to maintain, for their purposes, a sharp differentiation--such e.g., as the selective toxic action of drugs like strychnine, curare, etc. Such admission does not weaken the case for the proposal of the first paragraph above. We need merely to affirm our postulation that, in psychological optics, the activities of the sense-receptor mechanisms are dependent upon the framework of the executant motor mechanisms since even before tonus and reactance-level approach zero, sense-organ functions are nullified.

Perhaps the grossest and most common error in the past has been the belief that the primary source of all perceptual experiences was to be found in some sort of external sensory stimulation.

The weight of evidence is imposing and to the contrary. In the first place the myriad flood of afferent conduction at any instant is a pattern originating from practically all of our sense organs. To change this pattern radically all that is needed is to change the set, attitude or self-imposed instruction, or to superpose it upon a kinetic pattern which is incompatible. For example, hold your lips, tongue, and speech apparatus in the posture of just completing the pronunciation of the vowel O. Now have someone show you a card on which is typed a single word, with the instruction: Maintain posture and signal with your hand when meaning appears. Let the word be WATER. You note a definite strangeness and a manifest difficulty in following implicitly the simple instruction.

Further, as Purdy has shown, in the rivalry of two or more impulses lies the basis of disjunctive seeing. Unless there is some unifying factor, the end of every "stimulus pattern" could conceivably be nothing more than the empty meaningless nullity you experienced in the simple experiment of the preceding paragraph.

In children, rivalry is weaker. Seeing is more coherent. In adults, coherent seeing is, like laziness, an achievement, with the advantage over childhood, that he may see either disjunctively or coherently as he adopts one attitude or another. To see forms, shapes, things as figures set in the 'real' pattern of fore, mid and backgrounds is a form of energy collection and transformation that represents a unitary process, whose beginning and end I doubt that any man can localize, and more I doubt that any good can issue from the ascription to the "stimulus" of the force or forces that set the direction or the end of the process. Did not Dewey, as early as 1896 point out that the trouble with the stimulus-response doctrine (among others) was that always "The Stimulus" lies inside rather than outside the act?

In his studies of pursuit movements of the eyes, Dodge maintained that the executant form of the adjustive activity was the unifying agency at work in the perception of the movement of the oscillating object. The 'schemes for action' do not originate in or derive from the stimulus patterns. Lumley's subjects, learning a serial multiple-choice problem, "developed inklings of the whole long before they were able to go through it step by step with complete confidence" and with accuracy.

In perception the structuring of the separate components into a unitary pattern is always accomplished under the dominance of a fluent growth which is motor. When training has proceeded to extensive limits and the perceptual performance becomes very highly skilled, this performance is characterized

by a complete absence of any visual imagery and is marked by a feeling of aesthetic gratification which comes from the smooth running of the motor course which begins even before the stimulus pattern is presented to the eye. Repeated observations in tachistoscopic experiments have abundantly confirmed the fact that after exposure any stumbling or hesitation in the executant movement becomes an effective eraser and blocks the reproduction of the seen figure at that point.

As skill is achieved in the visual perception of forms, ground becomes nearer to figure; there is more articulation; there is greater coherence and unity in the process and figure emerges more sharply etched and more resistant to any distortion.

There is nothing intrinsic or unique about what is seen as figure. The figure is merely the name we give to that portion of the total field which by its strength, position, resistance to distortion and similar operational properties represents the focus or point of maximum potential within the field. It is necessary, of course, for us to realize that such potency may be achieved and probably always is achieved as a resolution or algebraic summation of both internal and external factors. This is evident if we consider the course of perception and the search for meaning when we look at a new or ambiguous figure. Many of the readers of this article will recall that on certain occasions I have shown on the screen such a picture of a cow. One thing amply illustrated by viewing this slide is that the emergence of figure seems to take place entirely independent of the total duration of looking, and of the direction of regard upon any specific portion of the picture. I have repeatedly observed that even after tracing the outline of the animal's head with a pointer, many spectators are still unable to disembed the figure. When the figure does emerge, it comes suddenly in a single bound. The transformation of the field is instant. I can think of no better illustration of the principle that field structuring into the pattern of a figure-ground organization is neither determined nor predetermined by any physical characteristic of the so-called stimulus pattern. We are forced, therefore, to the conclusion that a substantial fraction of the stimulus is already present in the neuromuscular apparatus of the perceiver long before any object is presented to the eye to be seen.

At this point, a word of caution should be sounded. There is a tendency in some quarters to go to unwarranted extremes in the abandoning of the sensation doctrine. If we postulate that the whole process of perceiving begins with the prodromal set of events which set the stage within the organism and subsequently largely predetermine the course of perception and memory and if we regard the energy change which we call the stimulus as a single external episode in the course of the total process, then it must be quite evident that we must not recklessly abandon the external energy change completely for to do so would be to destroy a highly essential portion of the total process. All that we are insisting is that we must not think in terms of a rigid artificial division into three phases or stages (the sensory, cerebral, and the motor) of a process which is in its most perfect state a complete kinetic unity.

Thus field organization in perception gives us a perfect paradigm for field organization in biology. Professor Child, for example, in his most recent book says, "The field is constituted by the gradients present.....the gradients are the vectors of the field and determine its extent and the orderly relations in it." "Realization of field potency in actual development is localized in the high region of the gradient or gradient system constituting the field simply because this region is the intensively active one." For Child, gradients derive basically from changes in metabolism. He argues that any agent which levels the metabolic gradients also stops the processes of dominance and isolation which are the means of development patterns of axiate, polar, and sagittal symmetry in organic development. It is interesting to note that advanced thinkers in the biological field are not all in perfect agreement with Child on this latter point. As a matter of fact, Speeman Parker, and Weiss dissent with the view that the primary agent of organization is the metabolic gradient.

There have been numerous efforts to localize the essential process of the form-meaning sequence in the brain. The afferent volleys undoubtedly do create isomorphic patterns there, and these are conceivably capable of furnishing the material substrate for all

the phases of perceiving, retaining and recalling. To me the most brilliant experimental and theoretical attack upon this problem is the recent monegraph of Kohler and Wallack: "Figural After-Effects." Without the slightest intention of criticizing so important a work it is none the less necessary to realize that any account of field-organization which disregards or minimizes the conspicuous role the effectors play throughout every phase of visual experience is bound to be but a partial and incomplete account. It has been repeatedly pointed out (e.g. by von Frey and others) that the visual space world cannot be constituted from visual components alone. The sensory impact is itself as a part of the total motor (i.e. energy regulating) mechanism as is the contractile and secretory work of the effectors themselves. It is simply an utter artificiality to single out an early portion of the process and give it a name, after which the name is treated as a real unit. This process is called reification and needless to say is to be avoided.

No matter what the pattern of impression, it undergoes a whole series of transformations as time goes on. What we recall is never what was in the original perceptual field; rather it is that thing stripped of detail, simplified and condensed along lines laid down by enduring long-section sets, attitudes, dispositions. The field grows or dies away; becomes aggregated with others.

Later we shall attempt to show how these considerations apply to the analysis and interpretation of visual skills; and to the reconstruction of anomalous seeing by an appropriate training program planned for each individual case.

Psychological Optics

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The building of the visual space skills has been recognized by leading genetic psychologists (e.g. Gottschaldt) as fundamental to most other forms of development. Skill, in this sense, I shall define as the reorganization of the cortical motor consequences of the excitation pattern. The excitation pattern is the aggregate of afferent impressions from whatever source at any moment, plus the active 'traces' of motor patterns set previously in the central distributor mechanisms in the behavior life history. In the active process of perceptual field structuring, therefore, it is necessary to inquire into the role played by the sense organs. Titchener wrote that "we always perceive more than is furnished by the senses." In previous papers of this series it has been emphasized that it would be tragic indeed if our eyes always reported in exact one-to-one ratio the intensities, sizes, hues, distances, etc. of the things out there comprising our visual worlds. It is a fundamental fact that our sense organs never transmit what they receive. They are compensatory mechanisms. They suppress, for example, the extremes of intensity. In color photography or painting, exact spectrophotometric reproduction is rarely, if ever tolerated. Curved lines are always seen straighter than they really are. And if you will study the mechanics of hearing you will learn that pressure in the endolymph within the cochlea remains quite constant over a wide range of frequency - intensity relations.

In the skin the distribution of sensitivity is discontinuous and punctiform. On the tip of the nose within a given area there are found thirteen times as many cold as warm spots. On the back of the hand the number of spots was half as many but in the same proportion. On the nose there were forty-four pain spots to one hundred and eighty-eight on the back of the hand; and pressure gave one hundred for the nose, and fourteen for the hand. When histological sections of the nerve supply to the two regions were studied, a felt-work of nerve fibrils was found under each, with no specifically differentiated terminal receptor structures for each qualitative variety of sense experience. And when the mapping is done as carefully as possible many times, the pattern of distribution of the spots is never the same. If a spot is found today within the top left quarter of a certain square millimeter, and just to the windward of a hair, it may be found there again only once in ten times in fifty repetitions of the mapping. In the eye, there are excellent reasons for doubting the duplicity theory, that there are but two types of photoreceptors - rods and cones. Detwiler and others have shown that there are transitional and intermediate types of structures - rod-like cones, and cone-like rods. Concerning the roles they play in seeing, we have only the most meager information.

It is difficult to define the term <u>receptor</u> satisfactorily. Reasons for this difficulty are at once apparent. As indicated above, we do not even know the mechanisms in the skin which furnish us our primary temperature discriminations. Further, we do not know how they get stimulated, or why we get the experiences of paradoxical cold and paradoxical warm. And pain is a pain - if you have ever tried to puzzle out what it is, and what is its mechanism. Roughly a receptor is a dendritic branch of a nerve which responds to some limited portion of the spectrum of radiant energy or to the impact of pressure, temperature, electric current, etc. But here again things are not so easy as they may seem. One example will show that area or number of receptors firing simultaneously is necessary in some sense modalities. A few years ago, we attempted to discover, in our taste laboratory, the number and kind of fundamental taste qualities. A fine capillary tube enabled us to deliver a solution to the orifice of a taste bud seen with a wide-field binocular microscope. Solutions of quinine hydrochloride, sucrose, and sodium chloride in two, four and eight times the

threshold intensity gave no qualitative taste differences. The conclusion seems to be that a single bud cannot be made to yield a qualitative impression. Further it is true that Scofield was able to show that when topical solutions of novocain were applied to the tongue, the first effect of the anaesthetic was to diminish motility, not the action of the taste receptors. Taste thresholds vary with the area stimulated and also with the regions of the tongue - greatest sensitivity being found in those marginal places where the curvature is greatest, and where the tongue is most massaged by the teeth. Dentists will tell you that patients may complain, after the fitting of their first artificial denture or plate, of a radical change in taste. Usually the normal function returns after a few days. Foods are preferred by young children at quite different temperatures than adults.

In the evolution of the central nervous system there has been a specialization and differentiation of the receptors. We still know all too little about them. In the course of evolution aggregates of receptors have developed into sense-organs. The sense-organ is often an accessory, non-nervous structure or mechanism which operates to protect or assist the receptors in performing their functions. In the evolution of the eye, from the simple light-sensitive spot on the tip of the rays of the star-fish to the human eye, there is to be found a wide variety of forms of the sense-organ. Accommodation is effected in some forms by the pressure of bony plates which literally flatten the globe; in others by the forward and back movement of the whole lens; and if anyone is deceived as to the simplicity of the mechanism of accommodation in the human eye, let him look to the literature. Certain facts stand. But the commonly accepted teaching of the flattening and bulging of the lens capsule by tension upon the suspensory ligaments from the ciliary is not mechanically possible. So, accommodation is still a problem, and like many other operations of our sense organs, a very complex one.

The eyes move and pause and in so doing exert definite influences on the truly visual functions. Rexroad some years ago developed an after-image which he projected upon a grey ground across which a thread was stretched. Upon fixation of a knot in the thread the influence of tonus and tension in the extrinsic muscles could be observed by moving the knot from side to side. The pattern of proprioceptive excitation from the muscle postures had such pronounced influence on the after-image that the author felt that the concept of the after-image must be extended, at least, to include the significant effects attributable to the accessory musculature.

Elsewhere, in these papers, brief descriptions of Stratton's early observations on the semi-pseudoscope was given. The 'insult' to the total sense-organ pattern and the resulting anisotropy of space in these instances is further proof of the assertion that much of seeing is non-visual. When we take size-constancy measurements with the observer in a 'normal' sitting posture, then in the prone dorsal and ventral positions, we get three different size - matches consistently. Although the angle of regard is the same in these three instances, the results differ markedly. The reduction in size, which should be the equivalent of increased distance, is greater in the ventral than in the dorsal or sitting positions in that order. These findings are at variance with the conclusions of Boring on the same question. For him, the essential factor in size-constancy is the angle of regard. If it is constant the apparent sizes are constant. Only further research can finally decide. But it looks like the changes in the postural components of the field which form a portion of the ground on which our space, size and form discriminations emerge bring figure changes independent of fixation or accommodation postures. Every clinician has seen persons exhibiting high Esophorias, checked by three or more measures of phoria, at far and at near who nevertheless could not fuse targets either at far or near whose separations of prism-effects placed them well within the limits of the phoria. If a phoria is an anomalous space projection then it is quite clear that many determinative agents can act to produce it other than mere position of the lines of regard. So again we must recognize that the sense-organ itself is a first region of transformation of the impression pattern and while important phases of field organization take place here it is entirely erroneous to look to the eye itself as the final determiner of resolving power, brightness, form size, position, distance, movement - in short, of any truly visual process.

The 'unity of the senses' (Hornbostel) is not a mere phrase. It has long been known that ocular nystagmus and the function of the semi-circular canals are closely associated. It is likewise true that all afferent impulses from sight, hearing, the skin and kinaesthetics are correlated in the midbrain. Since object and form identification do not occur below the striate it is evident that visual field structuring will be profoundly influenced by the ground supplied from the effector backstroke and from the proprioceptive components in the total pattern. The stage for seeing is set by these factors and the course of visual perception is dependent upon the appropriate interrelations of these activities. The kind of visual space world shown by any individual is largely derived from the movement patterns he has built for himself. These are non-visual and non-localizable and non-verbalizable. This is why it is to me extremely doubtful that purely visual measurements of visual space phenomena are true indicators of the actual functional proficiency level of an individual. If this is true we need to critically re-examine our tools for the measurement of binocular depth and distance, fusion, phorias, etc. If they are good now, there is every likelihood that by taking stock of modern theory we can make them still better.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

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It would be difficult indeed to think of a more important topic than the one which has been the object of discussion through the last half dozen or so of these papers - the structuring of perceptual fields. In the evening paper I read an article from a famous foreign correspondent. Nazis in Berlin are still loyal to the hideous thing - Nazism. Young Nazis openly assert they will begin at once to prepare for the next war. The whole perceptual framework so deeply imbedded that even the rubble of their homes and the scorn of the world of those who can give some proper and decent appraisal to life -- all these even cannot counterweigh the sinister predetermination of conduct springing from the tightly organized fields. Very important in social psychology and hence in economics, politics ...everything which touches people's lives.

A young surgeon scrubs up. He comes to our laboratory. He thinks he may have a visual problem, tired after three major operations. It is difficult to read and sustain interest and 'grasp.' Soon the torridest of movies induces sleep. Nothing serious, just a vague and unlocalized feeling that something is not quite up to par. He has heard something about 'muscle exercises' but his training has made him frankly skeptical. He is desirous of seeing for himself what, if anything, psychological optics has to say about such a problem -- if there is a problem. Without discussion or argument, we go to work. An hour later three pages of compact notes, figures, findings are before the two of us. It soon becomes crystal clear. A chaotic and self-defeating pattern at near point; a space structure which surely cannot go farther without hampering and interfering with his highly exacting and important work. Whole areas of his perceptual fields a virtual rubble. He was quick to see that habits can and do interfere with one another. He could note his own gains in particular functions in the first quarter hour of training. He is sure now he can whip his problem. Doesn't he insist upon the ambulatory treatment of his own patients? Doesn't he see how functions A and B and C and D and E must work in synergy if he is to see singly, binocularly, sharply and as the first stage in all his adjustory movements? Yes, he does. But our young friend is just another example of the terrific importance of field organization.

The trend of all motor processes is toward equilibrium; of all sensory processes is in the opposite direction. The key to all meanings lies in the executant movements which constitute the oldest of all the forms of language. If the sensory is the early, preorganizational phase of the series of events beginning with the upset equilibrium (the stimulus) and ending with the consummatory act then it is fairly easy to see that if one can accept and believe this sort of thing it is bound to give new and different direction to his personal and professional activities.

To perceive we must perceive something. To perceive is a transitive verb. It always takes an object. Unity and continuity are the most general features of the perceptual process. It is characteristically forward-looking and anticipatory. It seeks constantly in the effort to restore equilibrium for the motor outlet which can transform or even nullify the sensory disturber. "Only those experiences which determine adjustment have an objective reference" wrote G. F. Stout many years ago. Yet how modern and apropos does it sound today.

The motor traces can transform the sensory impression patterns. And they do. The more genuinely <u>active</u> the perceiver the more certain will be the course of training improvement. In the Schumann effect, for example, where a single point of light reaches a point on the nasal side of the retina and the posture of the globes orient to attain the best state of equilibrium they can, a verbal instruction giving rise to the incipient movements of orientation to a second temporal point of light, may cause

it actually to be reported as seen. Is this an artificially induced monocular diplopia? Can the reverse of such a process be the essential mechanism of combination or aggregation which permits you to see the cow I have often shown upon the screen as a perceptual illustration rather than two black patches separated by an expanse of void white?

A further example. Eating, like learning, is a fundamental biological and psychological device for energy collection, storage and transformation. Gotz trained chickens to eat as he wanted them. He used chickens because they were certainly free from linguistic and many other types of human prejudices. He saw to it that they ate only if they selected and pecked the larger of two grains of corn. When they had learned perfectly he arranged so that the larger of two corn grains excited the smaller of the two retinal patches. The chicks selected the larger grains even when the 'retinal image' was 1/30 the size case by the smaller of the two grains: Clearly, overt behavior is not predetermined by the geometry of sensory excitation.

In a somewhat similar experiment Revesez trained chicks to eat from the smaller of two areas. When the two areas were made of identical size but set in a field relation appropriate to make one look smaller, the chicks selected the one appearing smaller. The behavioral determinants of behavior are very real things. They work silently and unobtrusively. You have to search them out.

Now let us look closer to home. A young woman of 24, in October was a myope. PR acuity OU20/89. One eye 20/200. High Esophoria at near. Low stereopsis. Break and recovery points poor. Pursuit and fixations not too good. With the ophthalmoscope it took a -6 to see the fundus. She was trained until Spring. Acuity now OU at far 20/30. Orthophoria at far; 4 Exophoria at near, -2.50 to see fundus. Other things up and on the way up. She was told by a doctor of medicine "you are still a myope but you can see at distance." This comment raises some interesting questions not unrelated to our considerations of basic theory. I cite this instance for two reasons: to show that the names we give to things are sensible only if they are operational. A two horsepower motor is one which can lift a specified weight so far in one second. Secondly to ask how normal vision can be defined in any other terms than those defining proficiency of adjustment when equilibrium is upset?

It is important for us to realize that any pattern of impression, traced to its end points, will meet and activate correlate and coordinate regions of potential in the central distributor (the brain and cord) which are the traces of previous adjustory movements and their consequences. They will also meet proprioceptive patterns from the postures, tension in phasic muscles and glands which limit in space and time the field of the next contractile and secretory effects. These 'sets' may be weak or strong; simple or elaborate; transitory or, as Köhler and Wallach have shown, enduring.

With continued experience of a specified sort these sets become degraded in the central nervous system. They become subcortical or even spinal. Their role may be either to extend or restrict the course of action.

Suppose a new and strange object is seen for the first time. Action is delayed while the 'search for meaning' goes on. The portion of the experience supplied by the perceiver is weak or absent. He relies on the primary 'physical' properties of the exciting pattern. He sees in terms of relations as they are, devoid of the interpretative influences of cortical and sub-cortical motor frames of reference. His visual impression patterns are not specified as to space and time relations until he makes them so. At three years of age it is a matter of complete indifference to a child whether a picture is upside down or seen in the conventional orientation. If he can read a little later he reads as well with print inverted as he does in the 'right' position.

Perceptual processes begin as wholes, masses, undifferentiated regions. In the second stage segregation appears. Relations are noticed, of parts to parts and parts to wholes. Structuring proceeds to new levels of skill in seeing, and if extended by practice and the process of approximation and correction sufficiently, the third stage of recession begins. The purely visual processes are replaced by motor sets. In your darkroom or familiar home surrounds you do a very good job of 'seeing in the

dark' by the tactual, kinaesthetic, auditory and motor cues. Seeing becomes less and less visual, more and more motor, adjustory and executant.

Carried to still further development there is a restructuring of the field. Visual impression patterns become freed from inhibitory and distorting central interferences and seeing and imagery take on the characteristics of the eidetic phenomenon.

It is not at all impossible that in this sequence of events we have the answer to a preplexing question; how can we account for the difference so frequently met between the optical measurements in refraction and the phenomenal vision of a person?

Here is a lad of 15 years. He is 12 diopters Esophoria at near and 14 diopters Esophoria at far. At near point, therefore, if phoria is a derivative of convergence he should be able to see pairs of stereo targets separated by such distances that they fall within his zones of projection. But he cannot tolerate even a small relative base-out displacement and fuse at near. The same is true of Exophorias.

Try several observers with the pointer technique on stereograms EC10 and 110 of the Keystone series. Measure and interpret your findings. You will see that the same separations are not phenomenally the same. The grounds are different and the angles of regard are different, and the phoria index is different. Which is right?

We need to look into this matter very carefully. In fact we are doing so.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

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The visual spaces of psychological optics are several. The spaces of the single and double eyes; of the resting and moving eyes; of the macular and peripheral regions; of nasal and temporal and upper and lower retinas - all differ. Each of these in turn must be regarded, as Stern described the Ungestalt, as field structures in which the integrating factor is the self. But what is this thing called the self? Have we not, in previous papers, followed Weiss, Child and others in showing that any agent of organization is an emergent or derived property of field structuring and that vectors here are set in precisely the same way that the interplay and resolution of forces drive the sailing ship or set the pattern of growth and development in a plant or animal organism. Does Stern therefore mean to add, as agent of organization, some abstraction capable of gathering in to itself, in empathy, every impression pattern and turning them to its own particular account? I do not think so. F. C. Bartlett has pointed out, for example, that in every instance of the search for meaning, the effort to resolve the perceptual dilemma when some new and unclassifiable and hence action-suspending thing or process comes to us, will take a trend characteristic of the habitus of the perceiver. If he is pessimistic, involuted and has set narrow limits to his scope, or if the converse is true, the content and mode of its perceptual organization will tend either to meagerness of detail, simple and hard factual structuring or to elaboration, embellishment and projection beyond the givens. It is not unlikely therefore that Stern had just this sort of thing in mind when he felt that he needed the self as a subject for the transitive verb "to perceive," and that <u>some</u> rational and defensible agent of organization had to be found. Since this was true the aggregate of remembered or retained sets -- largely the residua of motor processes once involved in definitely useful or advantageous (but not necessarily so!) executant and consummatory acts, could be represented by the sort of shorthand word <u>self</u> to designate this aggregate. Nothing mystical and certainly nothing which does not accord with sound motor theory need be premised if one chooses to say thus that the self is the agent of field organization in perception.

But surely too we must realize that the very properties of such a concept clearly indicate that its position and function is that of a ground, primary to sub-grounds and both operative in the establishing and maintaining of figure saliency.

It is notorious that "in my father's house are many mansions;" that the self which operates at a scientific meeting; playing with children; among utter strangers: where no pressures demand that we play a part but can become 'real' - are many different selves. The 'real' one even may be largely a function of one's digestion, recognition by one's peers, the state of personal finances, fears, ambitions, etc. It seems to be largely a matter of when, where and how we look at the concept of the real self as to what kind of reality we get or can accept. It is in accord with the trend of these papers to find no special difficulty if one prefers to demand the introduction of 'the self' as the primary agent or basis of field organization, if it is clearly understood that self is purely an abstraction, a mode of occurence of other real things. Its essence is found in the patterns of activity which characterize the one locus of experiences common to them all. It is thus not unlikely that instead of postulating the co-conscious, the subconscious, the libido and the several psychiatric explainers for anomalous perceptual processes we may better simply regard such things or processes in terms of weakness, instability, fluidity, changing orientation or of high strength and systematization - in a word of differing degress or stages of developmental field structuring.

In the six papers since January of this year enough has been written to show that there need be no distrust of the soundness

of the underlying principles of the mechanism of field structuring. Take the principles of dominance, isolation and gradient formation for example. No living protoplasmic system can exist for long and interact with its surrounds without the development of many physical systems within systems. Let me repeat again that emphasis must be continaully upon the motor components (not the sensory!) and that the trend of the movement continuum, the whole basis of organic structuring is toward the attainment and maintenance of stable equilibrium.

Let us look for a moment at a simple case in seeing. If I sit in front of my house my some 165° of angle gives me an expanse of streets, rows of houses all different under blue sky and colorful white clouds in the late afternoon sunlight. I fixate a distant house, a gable on this house, a window within the gable. I use all my powers and strive to hold this fixation <u>while making the effort</u> to notice and report the objects and shapes in the eccentric field. Peripheral indistinctness and uncertainty begins only a few degrees from the small central solid form angle. I am suddenly aware that the center has blurred or has been lost if any part of the surrounds is <u>seen</u> clearly enough to describe or sketch it or to tell how many panes in a window, slats in a garden gate, etc. There is certainly no forewarning, no sense of innervation, that tells me that when I must note the detail of a chair in a neighbor's lawn which falls in the left nasal and right temporal fields the mere self-imposed instruction sets up, as Purdy has so ably described it, the now two opposing motor processes to fixate two places at once, and the result is disjunctive seeing mainly characterized by the blurring or figural weakening of the central or macular forms. Much blurring at the far point can be anomalous, not as a reduction of "acuity" but as an operational impairment of figure-ground structuring. Such disjunctive process as described above presents binocular projection with an impossible task for resolution as depth and distance (third degree fusion). Now let such observation be made by a man or woman with low rivalry rate, and with even a moderate phoria or anomalous space projection at far, and if he has created, from what Dr. Skeffington describes as prolonged concentration in a restricted area at near, a state of satiety in the cortex which virtually raises the competitive strength of the periphery to figure status, the stage is set for disjunction and 'poor distance form vision.' This is probably what is either often wrongly called myopia or what should be designated as a special sub-class or type of this disorder.

Halstead has recently shown quite clearly that in anoxis or oxygen starvation the impairment of the functions of the periphery comes early and with it a disjunction of object visual discrimination, which for aviators, workers in many industries, drivers etc., becomes a definite hazard to safety. And only recently there has come to my desk an abstract of a paper by Walter M. Coleman, an English physiologist printed in 1920, in which he shows that by voluntary creation of states of apnoea and hyperpnoea (subventilation and superventilation of the lungs) rivalry, essential to stereopsis, can be abolished or restored. In one experiment Coleman showed that with excess oxygen "panoramic after-images alternate between the temporal and nasal fields;" with subventilation of the lungs "they alternate between the two eyes." If the upper and lower halves of the retinas are excited their behavior is quite different from that of the nasal and temporal halves.

In a previous paper in this series it was pointed out that the rate of rivalry with simple figures can be materially increased by training. It has recently been shown by Dr. Max Daniel and also in the laboratory here, that increase in rivalry rate is accompanied by increase in the stereothreshold. Further work along these lines is now in progress.

At the recent St. Louis conference on visual training a significant reference to field structuring or figure-ground organization appeared in several of the reports on various studies. More will be heard in the future, of the developments in the control of this important phase of visual diagnosis and training.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

SUMMARY

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The objective of this paper is to condense in brief compass all the important things said in the eleven papers which comprise Volume 5 of this series. Such a task on such a day when history is being made, at first leaves one somewhat cold. But history is also in the making in our fields of common scientific interests. When the summary can be written of how far visual science has advanced in the past few years it will be seen that these have been great years. And no small part of the true greatness of these years will be marked by the advances made in basic theory. It is only as we set the plot, the basis of organization of our activities in research or in practice, that we move forward without the subsequent necessity of retracing our steps. It is doubtful if so many people have ever realized so clearly the true importance of fundamental research based upon sound principles of theory. It is also true that we have probably never faced a time when so few young men approached the threshold of the laboratory or the professional office with the kind of training most suited to carry forth both their own and the future advancement of science.

It therefore seems now timely that last October we started by raising the very important questions: What is science? What are its processes? Tools? How does one division of science differ from another?

Science sets out to describe the things, processes and interrelations amongst them as they occur in nature. It does these things as all human beings must -- with the aid of sets of sense organs, central distributors and effectors, together with the special mechanical devices we have contrived throughout the ages to extend the ranges of these functions and thus to multiply the number of statements and to reveal the interrelations existent among and about the things and processes in nature. The first important difference between the scientific way and the non-scientific way of attacking a problem lies in the fact that the former first sets up a set of postulates. These are definitive. They set limits to problems and methods. They clearly define the boundaries of interest and activity.

Psychological Optics secures its right to existence from the fact that it postulates the reality of emergent functions, unpredictable and undescribable within the scope of the postulational limits of the other divisions of science. Seeing, regarded as a total function and not a mosaic of separate part processes, has attributes and operational manifestations which the conventional concepts of physics, physiology and neurology do not include. Such a view does not ever in the slightest deny the basic reality of the physical mechanisms of seeing. It simply insists that we must go a step farther; that we have also a province of phenomenal or experiental reality to deal with, one whose ultimate importance to us is very great.

Concretely, the size of any visual object is not covariant with changes in the size of the retinal patch stimulated. When the patch is reduced to one-ninth in area, for example, the object still looks about one-fourth as large. Prolonged inspection of a curved line leaves us incapable of seeing a straight line as straight in certain regions of the visual field. Contrast effects may be made to go with or against the rule or to be completely ablated. These are descriptive and interpretative jobs for psychological optics. Two problems alone would supply ample justification for psychological optics if no others existed: visual space, and the transformations in functions consequent to learning and training.

The November paper followed with a consideration of the problem of the relations of form and function. "Function...is...the basic set of forms which energy takes in the never ending process of its collection, storage, dissipation and reconversion which comprise the electrochemical basis from

which life itself originates." Form, from one point of view, is an episode in function. The structure of protoplasm as colloidal emulsions was considered briefly and the earliest beginnings of gradients and of formal organization in living single cells was pointed out. The discovery of the cell and the formulation of basic principles of structural organization in living things has been a development of about the past three quarters of a century. In December the cell as an intricate electrochemical system was treated. Both internal and external changes determine behavior. Stimulation upsets an equilibrium state and the return or restoration of equilibrium constitutes behavior.

In the earliest stages of cell development the local changes occasioned by energy adsorption at the surface is the beginning of reactance. Stimulation itself is merely that phase of the total motor activity which precedes an arbitrarily defined point in space or time. Polar gradients and axial patterns are formed consequent to the establishment of regions of high activity, or metabolism. The high activity end is <u>dominant</u> and the whole cell becomes organized <u>through activity</u> into a definite organic form or structure. Arguments were presented showing that too great emphasis on the sensory and not enough attention had been given to the motor aspects of organic life and function in the past. Child's concept of the origin of the nervous system "in protoplasmic behavior" was introduced and the role of the dominant or pace-setting region was pointed out. Blocks, either organic or functional, may move the control from the higher toward the lower end of the gradient. In vision the implication is clear, although unexpressed, that similar effects may be observed in the retino-cortical-effector field. Mass action, as described by Coghill, Minkowski and others is primary and out of it is differentiated the later specific habit patterns. The basis of organization in organic nature thus demands no expletive beyond the objective observable facts of behavior in living protoplasmic systems, "not by some capricious 'unfolding from within' but by the active interplay of forces which aggregate on the two sides of the plasma membrane."

January showed that hand in hand with <u>dominance</u> arises the concept of <u>isolation.</u> Any region that becomes dominant also becomes relatively independent of other lower lying regions. Isolation is usually followed by significant behavior changes. Parts isolated lose their characteristics as parts and tend to approximate the condition of a whole new individual. Whatever decreases dominance places an active upsurge upon posterior regions of the gradient to change behavior and form in the apical direction. In visual field structuring this fact may also be seen in the macula-periphery relation, the peripheral blocking of macular discrimination for example.

A second way in which isolation can be established was pointed out: prolonged and repeated stimulation of a subordinate region may develop it into a region of secondary dominance and thereby achieve as much of a relative independence as local conditions will permit. Such a principle could furnish another basis for the figural after-effects described by Kohler on a more purely biological basis if this is preferred to the purely physical theory of satiety or electrotonus reported in Kohler's monograph. In review it is suggested that even though a careful reading of this paper was given originally a more careful and thoughtful rereading may not be amiss, particularly for those who have first hand familiarity with the highly important paper of Kohler mentioned above.

Next (February) development was defined and distinguished from growth, following the arguments of P, Weiss, Speeman, and others. A new interpretation or meaning of the term for psychological optics was given (p.15). The anisomorphic distribution of energy in a field opened the whole question of filed structuring, which became the topic of papers 6 to 11, pages 19 to 40.

March quoted from Purdy's papers in which if non-homologous retinal areas are simultaneously stimulated a tension posture is instigated. Such coagency of antagonistic extrinsics may block or transform retinal or other excitation processes.

Every perceptual theory, Kohler believes, must be a field theory. Within the field those portions which achieve <u>saliency</u> become figural. These figures or shapes have definite boundaries and definite properties

which demark them from the sustaining grounds from which they emerge. Part of the ground derives from total body posture.

Fields may be greatly complex, containing many sub-regions, and the process of structuring may result in a pattern of no great stability. Part of the paper was devoted to show how the field concept has developed in biology as well as in psychology. In biology a field may be merely a gradient produced polar axis of symmetry, or it may be the formation of a sub-regional field such as a limb bud or even a whole endocrine system. In all instances the direction of the unifying influence is "from above," in contrast to the view of tradition. Fields are real things although they cannot be seen under the microscope.

In the April paper <u>fields</u> were defined as "dispersions or distributions of energy in space forming a pattern or structure." Fields not only influence other fields but set certain controls over intermediate regions. Changes in pattern of field structure can occur suddenly. This may occur just as does phase reversal in colloidal emulsion systems from the action of the interfacial film or from catalysis. In vision the reversal of perspective in certain types of 'illusions' is probably a similar case in point. External reality may "be more a matter of inner than of the outer portions of the field" which is simply another way of saying that the perceiver actively structures his fields of phenomenal experience and is not the mere passive recipient of whatever comes to him. Weiss speaks of a field as "the condition to which a living system owes its typical organization and its specific activities." He lists a half dozen properties of fields, to which list the writer adds three more:

1. Fields originate from body activities and their interrelations.
2. Fields are unities and not mosaics.
3. They tend to maintain themselves. The stable equilibrium is a field pattern.
4. They vary in three dimensions of space and are often multipolar. Their effects may differ in opposite senses along the same polar axes.
5. Fields may change in size without altering relative proportions.
6. Splitting and fusion may occur with accompanying changes of influence depending upon spatial and temporal relations of the final total pattern.
7. Fields have a fourth dimension -- time -- in which regular and systematic changes take place.
8. Active energy change is a basic character of any field. Grouping produces emergent effects conforming to long section temporal field structures. Language, memorial functions of symbolism and other perceptual elaborations are the agents for maintaining the plot or plan of organization.
9. Stimulation and response are both agents of field organization which determine the amount, rate, and limits of visual functions. The field structure is the primary thing.

Field theory is not limited to any one or two divisions of science.

In mathematics the development of group theory is further evidence of the universality of the principle.

In May we pointed out that the basis of disjunctive seeing lies in the active competition of two active antagonistic regions (Purdy) and that the acquisition of perceptual skill in seeing follows that same pattern as it does in a manipulatory skill. Some of the characteristics of the figural process were described and attention was called to the importance of regarding the prodromal set, the impression and all the chain of subsequent events as essential portions of the single and unitary process in perception.

In June it was shown that the building of visual space is fundamental to most other forms of visual skills. Simple position is an early and essential element in developing by tachistoscopic methods the accurate perception of unitary forms. A skill was defined as "the reorganization of the cortical-motor consequences of the excitation pattern," the last two words of course including those determinants of mnemic character which form a portion of the essential ground for the process. The first part of the paper was devoted to an inquiry into the further role of impression and to the difference between the role of the sense organ and the receptor.

Stress was placed upon the non-visual supports of the visual processes in the hope that some critical thinking might follow

regarding the methods, instruments and interpretations used in the measurement of binocular depth and distance, stereopsis, phorias, etc. July reported that "the trend of all motor processes is toward equilibrium and of all sensory processes in the opposite direction." The key to meanings lies in the executant movements and the perception of the consequences of these movements. Unity and continuity are the chief attributes of the perceptual process. It is forward looking and anticipatory. It seeks constantly to restore equilibrium by the degrading of the sensory disturber. Normal vision is only definable in terms of operational adjustment when equilibrium is upset. Perceptual processes begin as wholes, masses, undifferentiated regions. Segregation appears in the second stage and relations are noted of parts to parts and of parts to the whole. Thirdly structuring proceeds and as skill is attained recession begins. The purely visual processes are replaced by motor sets. In such developmental series is to be found certainly some of the main differences between the refractive or purely optical and the phenomenal visual status of a person. In August we closed the series with the notation that in psychological optics there are many spaces, the common ground for whose unification Stern regards as the self, a sort of shorthand way of designating the aggregate of one's whole organic field. The "trend of the movement continuum, the whole basis of organic structuring is toward the attainment and maintenance of stable equilibrium." One should add that such a state is dynamic rather than static for it is, to quote Shakespeare, "in form and movement" that man is so "express and admirable."

If this 1945 series had laid a foundation in your thinking to show the essential soundness and unity in all the divisions of science of the important principles of structure, organization, individuation and that the chief determinants of development are orderly and work "from above," we have made some progress. It will now be easier for us to go the next step in 1945-46.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

THE INFLUENCE OF TACHISTOSCOPIC TRAINING AT FAR POINT ON THE SCHOLASTIC ACHIEVEMENT OF FIRST GRADE CHILDREN

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This is a report of findings of a year's study of the influence of three twenty-minute tachistoscopic training sessions weekly from September, 1944 to June, 1945, given to approximately one hundred first grade children in the schools of the city of Gary, Indiana. These experimental children comprised three classes from three schools selected to represent high, medium and low socio-economics levels. Three control groups from comparable schools received the same scholastic experiences throughout the year, except the control children received no tachistoscopic training. Standard tests of accomplishment of several different types were given at the beginning, at the middle and at the end of the school year. The object of this report is to present the results of the year's study and to show the extent of the influence of training children to see and reproduce visual forms upon the rate and amount of learning to read, to deal with numbers, etc. in the first school grade.

It is a pleasure to credit here those who made the study possible: Superintendent Charles D. Lutz of the Gary Schools was most helpful and cooperative: Miss Maryalice Quick a specialist in the Child Welfare Department of the Gary schools, personally conducted all the training sessions, did much of the planning of the content and form of the training sessions, and was largely responsible for the careful testing and tabulating of results for all the experimental and control children. To Miss Quick, more than to any other person, belongs the credit for the carrying out of the program according to plan. Our obligation to Miss Jones, of the Gary Bureau of Tests and Measurements is great. She and her staff did a fine job of testing. Drs. E. B. Alexander and A. M. Skeffington of the Optometric Extension Program and the Graduate Clinic Foundation, supplied the funds needed to defray the major expenses. The Three Dimension Company of Chicago loaned the equipment - tachistoscopes, screen and slides. The superintendent, principals and teachers of the Gary Schools were sympathetic, cooperative and helpful in full measure.

So far as is ascertainable this experiment represents the first time whole groups of unselected primary public school children have, during the first school year, been given tachistoscopic form training three times weekly for a total of 106 training and testing sessions.

Let it be entered in the record here and now that the evidence to be presented in the tables and graphs to follow and the demonstrations made by the trained children before school officials, teachers, and parents in Gary, is clear and unambiguous: children who have had adequate tachistoscopic training in the first grade read more fluently and understandingly, show distinctly greater skill in numbers work, exhibit a greater range, quickness and accuracy in general observational noting, in art work, etc., than children of equal native ability, under teachers of equal competency in the same curriculum, who have not had this form of visual perceptual training.

Such a generalization can be further supported. Four other similar experiments were made during the past year: one at Texas City, Texas by Dr. Fannie H. Melcer and Miss Barbara Brown with first-grade bilingual Mexican - American children; one at National College, in Chicago, by Dr. Vivian Ilg; and one in Bexley, a surburb of Columbus by Dr. Josephine MacLatchy; one by Dr. Fred Bay, in the schools of Dover, Ohio. All confirm and agree with the findings of the Gary study.

When an average child at age six enters school his sensory-cerebro-motor mechanisms are read to begin the acquisition of the many habits he must have to live in our culture. His language development is limited. His world of space, time, motion, form,

size, position, distance, etc., is nothing like that which you and I experience as adults. These skills he must acquire. Small wonder that, for him, 2 and 5, 3 and 8, 7 and 9; b, d, p and q are confused, confusing and ambiguous. He must learn to see forms; to localize or project the isomorphic processes in his nervous system to precise spatial positions out there; he must aggregate parts into wholes and segregate parts from wholes.

It is fairly well agreed that perception is a process of field organization or structuring - "seeing things together" - which begins with masses, totalities, unities and proceeds later on to specific differentiations.

It is also true that when seeing is disjunctive, when separate and successive fixations break up the unity into a set of discrete parts, the registration and subsequent recall of what was seen will be disjoined, and errors of what, where, and when are the rule; accuracy or true isomorphism is the exception. The short exposure of a visual form is one means of enforcing the seeing of forms as wholes or unities. But the short exposure alone is not enough. It must be given as the first term in a series of active events consummated by the perceiver himself. He must be trained to grasp the total impression and to fix it in retention by the immediate motor consummation of speaking, writing, drawing, mimicing or other form of manipulatory response. Meanings are always kinaesthetic. They derive, not from the sensory attributes of the stimulus, but from the behavior vectors which follow upon and subsequently transform the stimulus.

Can six year children be trained to perceive visual forms in conformity with the best and soundest of modern psychological theory? What limits can be attained in perceptual skill from three training sessions weekly for a scholastic year? What demonstrable effects will this training have?

Let us bear in mind that when school opened in the first week of September, 1944, in Gary, few if any of the 113 experimental and 119 control six year olds could name and identify the digits or the letters of the alphabet; nor could they write them, even to copy a figure 8 or the letter G was a laborious, difficult or almost impossible task. It is a fair statement that the children, their teachers and Miss Quick set forth upon the years enterprise 'from scratch'. In the first year the average child is expected to show a certain attainment of skill in simple operations with numbers, he forms letters and numbers on paper or blackboard, he reads from books carefully suited to the stage of his language development. To do these things he must see shapes rapidly and accurately. If he reads "words, words, words" his understanding portends "an infinite deal of nothingness." He must group, structure, organize into larger and larger perceptual unities. The logical order is letters, syllables, words, phrases, sentences, paragraphs, sections, chapters, and beyond. But the theory we seek to test holds that the true, natural developmental order in perception is the reverse, and that tachistoscopic training of the proper sort will make achievement greater, imbue him with the feeling of mastery or aesthetic gratification which accompanies the growth of competency and set the course of sound mental habits which, if continued in subsequent grades, may prevent the waste of failures or indifferent achievement.

Of particular interest, too, to many of us, is the fact that sharp, alert, visualizing of forms at far point should be a wholesome and hygenic and natural exercise for the forming patterns of visual skills at age six. How many more of the 113 experimental than of the 119 control children in June 1945 had built a solid defense against spatial and formal anisotropy, against the beginnings of progressive or school myopia? Our original experimental design included at least three visual skills checks. It is regretted that we have no data on these very important questions, due to circumstances over which we had no control. So this report deals singly with tachistoscopic training. Barring sampling errors and assuming equal or near equal distribution of ability to learn in the experimental and control children, and assuming that goodness of teaching, and other such factors were approximately equal, we may conclude that we may attribute to our training differences in achievement, shown by standard tests, judgments of teachers, parents and trained observers,

which show the experimental children superior to the controls.

Here it is customary to establish the proof of causation of the difference due to tachistoscopic training <u>and to no other agent or factor</u> by certain clever statistical devices. <u>How much</u> superior in numbers work or in reading skill must an experimental group be so that we may be virtually certain of the causal linkage? A difference divided by its own root mean square error gives a quotient which, if certain stipulations are true, can be expressed in terms of the probability coefficient of the questioned causal or associative relation. This is one of several possible approaches to the problem. Still another is to regard the test score evidence as a not-too-true picture of the very complex perceptual functions of each individual child, to hesitate at too much pooling of the naturally non-homogenous class groups; to regard the qualitative and observational evidence of child performance as valid in their own right and hence at whatever risk it entials to assume that any differential gain in skill is a true gain in skill. All the years data are at hand - a small mountain of papers - and is available for any form of serious analysis and study different from what follows. Let us look at the record.

Table I gives the distribution of the intelligence quotients of the children at the beginning of the year. The Edison, Horace Mann and Froebel-G first grades were selected as experimental and the Ambridge, Jefferson and Froebel-B classes as control groups.

In ability or intelligence the averages and ranges of Edison and Ambridge, of Horace Mann and Jefferson and of the two Froebel groups are closely similar.

Table 1

DISTRIBUTION OF IQ'S

School:	Edison	H. Mann	Froebel-G	Ambridge	Jefferson	Froebel-B
	Experimental Group = 113			Control Group = 119		
I.Q.Range	Number of Children in each range					
130-139	1	1	0	0	0	0
120-129	2	1	0	2	0	1
110-119	8	1	0	8	7	1
100-109	10	8	2	11	3	0
90- 99	8	13	6	14	9	6
80- 89	5	12	9	7	16	11
70- 79	1	6	13	0	5	12
60- 69	0	0	6	1	1	4
	35	42	36	43	41	35
Average IQ	102.8	93.0	80.0	100.0	92.0	82.5

It may help to recall that IQ's of 90-110 are regarded as normal or average, 110-120 superior, 120-140 very superior, and over 140 genius or near-genius. 80-90 is classed as dull; 70-80 border-line deficiency "sometimes classifiable as dullness, often as feeblemindedness," and below 70 "definite feeble-mindedness." (Terman.) The poorest 1% of children test 70 or below; poorest 5% test 78; 10%, 85; 20%, 91. The top 1% reach 130 or above; 5%, 122; 10%, 116; 20%, 110.

Later we shall return to this table when we examine achievements. The Froebel-G and B groups may be compared. The Edison and

Horace Mann, and the Ambridge and Jefferson groups may similarly be compared, as experimental and control groups. Note that the ranges in each class cover the gamut from the top 1% or 2% to the poorest 1% or 2%, with the exception of the Froebel groups where but 16 of the 71 children rate above IQ 90; and 35 of the 71 stand at 80 or lower.

From the point of view of the range of children we were fortunate. We had 33 children of IQ 110 or better and 8 better than 120. Of these 8 it can be said that they are equaled or excelled by about 3 out of 100 children.

Gary is a city whose population is said to comprise some 56 nationalities. In many homes little or no English is spoken. In others, the purest Back-Bay Bostonian. The Gary schools have been famous for many years for superior educational productivity with children of cosmopolitan composition to be found in few American cities.

A variety of tests were given to all experimental and control children in September, January and June. Among these were the Metropolitan Achievement, Gates Primary Reading, Gray Oral Reading, Lee-Clark Reading, and the Pintner-Cuningham Mental Test. At mid-year, as could be anticipated, development of skill and achievement had not progressed far enough to make any significant differences in the test scores of the experimental and the control children. Consequently we shall limit our exhibit of comparative findings to the results at the end of the year.

Figure 1 (attached) shows the achievement of the Edison (experimental) and Ambridge and Jefferson (Control) group in Average Arithmetic. The mental abilities of the three groups are about equal. Teaching in the Ambridge group is rated as superior and in the Edison and Jefferson groups as average. The marked superiority of the experimental group (Edison) in Arithmetic is obvious. This figure is read as follows: The top fifth of Edison children averages 3.2 grades at the end of the first grade, the standard being 1.9 grades. The second fifth averages 3.1 grades, the middle fifth 3.0 grades, etc. 80% of the Edison children average 3.0 grades in Arithmetic or 1.1 grades above the standard. The top 80% of Jefferson (control) children average 2.5 grades or 0.6 grade above the standard. The difference in favor of the tachistoscopically trained children is a half-year of Arithmetic achievement. The Edison superiority over the Ambridge averages 0.4 of a school grade.

Figure 2, (attached) presents the comparison of Total Achievement in terms of the Metropolitan Test scores. Note again the superiority of the Edison over the Jefferson group and also significantly that although the Ambridge group received the best first grade teaching in the city, the comparative standing of the Edison and Ambridge group must be regarded as equal from the lowest to the highest fifths of the groups. From such findings, it could be argued that tachistoscopic training can compensate for the difference between average and superior teaching, other factors being equal. Such tentative hypothesis, of course, needs further testing and verification.

Table 2

METROPOLITAN ACHIEVEMENT TEST

School	Edison	H. Mann	Froebel-G	Ambridge	Jefferson	Froebel-B
	n = 30	n = 33	n = 27	n = 36	n = 36	n = 26
	Experimental Groups			Control Groups		
			Average Reading			
Quintiles						
(1)	2.88	2.60	2.60	2.90	2.66	2.55
(2)	2.58	2.18	2.25	2.70	2.10	2.14
(3)	2.20	1.83	1.86	2.56	1.90	1.80
(4)	1.90	1.50	1.54	2.24	1.46	1.30
(5)	1.60	1.30	1.18	1.90	1.20	1.20
			Average Arithmetic			
Quintiles						
(1)	3.20	2.70	2.83	3.01	3.00	2.80
(2)	3.06	2.30	2.63	2.80	2.64	2.54
(3)	2.98	1.85	2.26	2.60	2.40	2.16
(4)	2.70	1.73	1.90	2.37	2.00	1.90
(5)	2.30	1.50	1.46	2.25	1.63	1.48
			Total Achievement			
Quintiles						
(1)	2.90	2.63	2.66	2.90	2.70	2.60
(2)	2.66	2.20	2.33	2.70	2.25	2.24
(3)	2.45	1.90	1.98	2.55	2.10	1.90
(4)	2.15	1.60	1.66	2.30	1.60	1.70
(5)	1.83	1.40	1.26	1.90	1.30	1.36

Table 2 gives the quintile averages for Average Reading, Arithmetic and Total Achievement on the Metropolitan Test given in June, 1945. Of particular interest in this table is the comparison of the two Froebel groups. Note that in spite of low ability 80% of both groups are at or above the grade standard in Arithmetic. Tachistoscopic training does not produce the same difference between the experimental and control groups with children of lower mental level (see Table 1). The poorest showing of the Froebel group is in Reading, the top 40% of both groups being above the grade standard of 1.9 but comparing surprisingly well with the Horace Mann experimental children. In general, from the results of this test, one must conclude that tachistoscopic training with children of I.Q. level 80 is relatively unproductive. The problem of securing and holding attention during the exposures may hold part of the answer to this question. Some light on the question may be seen from the comparison of the Edison and Horace Mann experimental groups. The Horace Mann discipline was poor. Compare the Arithmetic, for example, of Edison, Jefferson and Horace Mann and in spite of equal abilities the achievement differences are marked.

Figure 3 (attached) presents graphically the scores on Average Reading. Again Edison shows marked superiority over its control, Jefferson; and the top 40% of Edison is about equal to Ambridge, where in all probability teaching differences account for the Ambridge superiority of the three bottom quintiles.

Figure 4 (attached) shows Word Recognition Gates Test scores. Here the superiority

of the Ambridge group is marked with Edison not much superior to its control, Jefferson. We should expect just this sort of finding. The whole purpose of tachistoscopic training is toward large perceptual unities, toward coherent rather than disjunctive seeing. Look now at Figure 5 (attached), which shows Sentence Reading. Twice as many Edison children are at or above the grade standard as Jefferson. Ambridge again is better than Edison except in the top fifth. In Figure 6 (attached) we see Paragraph Reading. Here the Edison children are distinctly superior to Jefferson and equal in the top 40% and only slightly inferior to Ambridge throughout the remainder of the range. We should expect just this.

Table 3

GATES PRIMARY READING TEST

School	Edison	H. Mann	Froebel-G	Ambridge	Jefferson	Froebel-B
	n = 34	n = 35	n = 32	n = 36	n = 39	n = 30
	Experimental Groups			Control Groups		
			Word Recognition			
Quintiles						
(1)	3.06	2.74	2.58	3.20	2.88	2.62
(2)	2.50	2.04	2.11	3.10	2.38	2.08
(3)	2.21	1.96	1.75	2.47	1.91	1.83
(4)	2.05	1.43	1.45	2.27	1.41	1.58
(5)	1.51	1.04	1.25	2.02	1.24	1.26
			Sentence Reading			
Quintiles						
(1)	3.02	2.49	2.65	2.98	2.50	2.34
(2)	2.25	2.17	2.15	2.70	1.96	1.85
(3)	1.95	1.70	1.57	2.57	1.63	1.57
(4)	1.88	1.51	1.55	2.45	1.53	1.50
(5)	1.48	1.39	1.38	2.12	1.41	1.07
			Paragraph Reading			
Quintiles						
(1)	3.50	2.60	2.94	3.45	2.79	2.82
(2)	2.77	2.11	2.31	2.95	2.22	2.21
(3)	2.40	1.90	1.93	2.85	2.00	1.90
(4)	2.10	1.72	1.58	2.35	1.70	1.67
(5)	1.69	1.51	1.49	2.01	1.49	1.43

Table 3 gives the quintile averages on the Gates Test. Figure 7 (attached) presents the results of the Gray Oral Reading Test for Paragraph Reading. Note the similarity of general form of the distributions to the Gates Test on paragraphs. Here only the upper half of each group shows achievement beyond the grade standard with Edison and Ambridge clearly superior to the control group at Jefferson. Figures such as these do not tell the story as we should like. For example, a comment by the classroom teacher at Edison, from the entry in her notebook on June 15:

"This group of children are the most interesting group I have had in Gary. They have so much to contribute. They are so eager to learn. They are independent workers. The children never tire of reading. Some

of them would read all day.

"This training has helped them in many ways. It has improved their comprehension and taught them to really see. They are more advanced in all phases of number work.

"This training has really done something for these children. They read with more fluency and meaning."

Many teachers and principals have observed that the trained children work better. For example, the Head of the Gary Testing Department commented on June 5: "Some people think first graders do not know how to work. I would like to send them out to visit (the Edison Group). You should be proud of your work this year. They respond so well and I saw no cheating. They work the best of any group in Gary."

There is a conviction in the minds of all of us who observed these children that the main values of the tachistoscopic training will show themselves more for the trained children in the second and third grades and beyond. Art teachers in both Gary and Bexley report that trained children see, with a marked superiority over the untrained. Of course much more experimentation needs to be done in the early grades. It is my conviction that tachistoscopic training, properly given in the first three grades, will become in a few years a most significant and important development in elementary education.

Finally, let us look at the amount of tachistoscopic skill gained by our trained children in the first school year and compare it with the controls.

Table 4

FORM PERCEPTION TEST RESULTS

January 23-26, 1945

School	Edison	H. Mann	Froebel-G	Ambridge	Jefferson	Froebel-B
	n = 32	n = 32	n = 30	n = 34	n = 31	n = 34
	Experimental Groups			Control Groups		
	Percentage Correct			Percentage Correct		
Numbers						
3 digits	39.5	26	22.2	21.5	6.45	20.5
4 digits	2.05	3.12	0	1.96	2.14	0
Words						
3 letters	51.6	62.8	45.5	32.8	17.06	10.6
4 letters	4.8	3.2	0	1.9	1.47	0
5 letters	35.4	8	6.5	0	0	0

Table 4 shows that in January there is a marked superiority of the trained children on both digits and words.

Table 5

FORM PERCEPTION TEST RESULTS

May-June, 1945

School	Edison	H. Mann	Froebel-G	Ambridge	Jefferson	Froebel-B
	n = 23	n = 24	n = 26	n = 30	n = 21	n = 20
	Experimental Groups			Control Groups		
	Percentage Correct			Percentage Correct		
Numbers						
3 digits	55.22	50	28	24.3	15.4	17.5
4 digits	16.3	11.7	3.7	2.3	0	3.3
5 digits	.816	0	0	0	0	0
6 digits	0	0	0	0	0	0
7 digits	0	0	0	0	0	0
Words						
3 letters	55	43	31	28	19	3
4 letters	17	12	11	8.4	3	2
5 letters	5	7	4	1.1	.03	.8
6 letters	2	1	2	.870	0	1
Phrases						
5 letters	16.1	9	8.6	10.8	2.6	0
6 letters	20.4	14.6	16.6	10.8	1.8	7.7
7 letters	12.1	3.9	6.04	13.5	2.7	.96
8 letters	16.1	16.6	12.7	12.6	1.8	1.27

Table 5 shows the results at the end of the year. Trained children correctly reproduce about half of the 3 digit and 3 letter words and about 1/6 of the fours. Fives and sixes are too difficult for them.

Obviously the expansion of grouping and real tachistoscopic skill lies ahead. It is regretted that the same experimental children are not carried on this year in their second grades, and then in the third. The educational and visual return would undoubtedly be great. A good beginning was made however. If everyone who reads this report could observe the top 20% of these trained children read, draw, letter, figure, etc., even from books written for fifth and sixth grades, there would be no question.

Adding 1/4 to 1/2 a year of achievement or more is certainly worth while from any viewpoint.

Finally it should be noted that this first year's work was wholly experimental. Materials and methods were not perfect. The amount, kind and order of training could be greatly improved, based on experience. The consensus is without question: even a modest gain in perceptual skill produces a result of great value; it is tantamount to the difference between average and superior teaching; it does something of great value for the slower, duller children, and far more proportionately for these whose abilities are good.

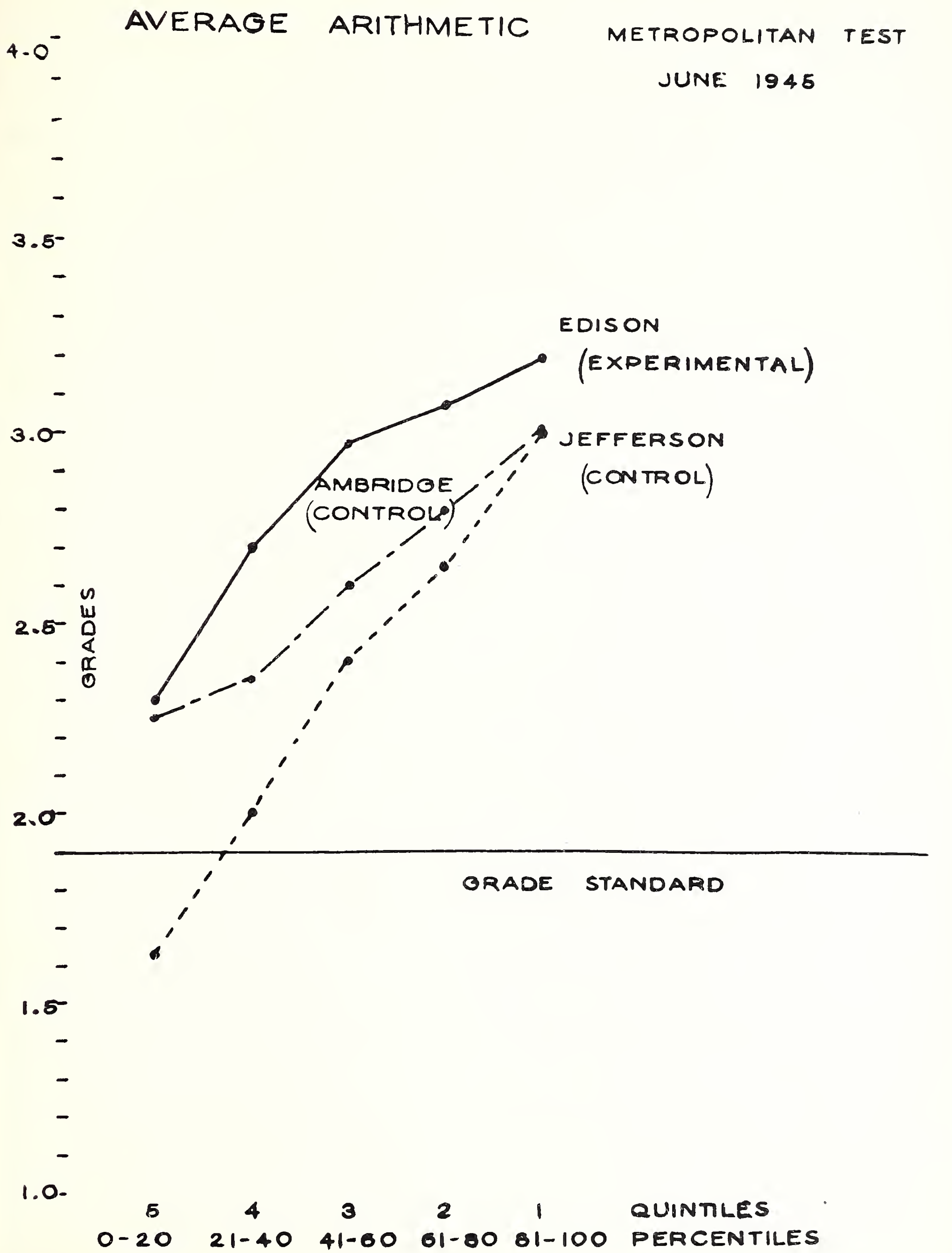
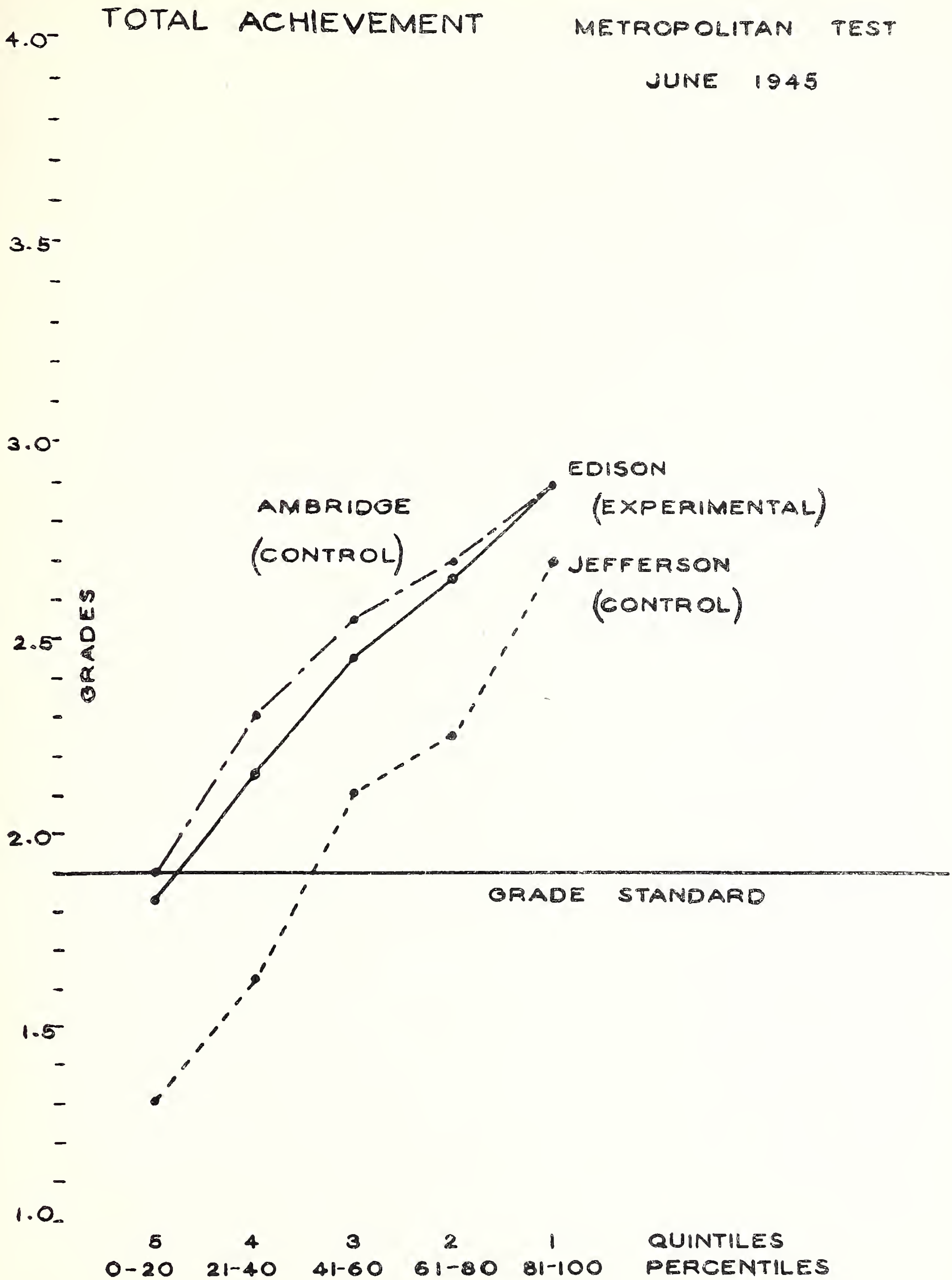

AVERAGE ARITHMETIC
METROPOLITAN TEST
JUNE 1945
4.0
3.5
3.0
2.5
2.0
1.5
1.0
GRADES
EDISON
(EXPERIMENTAL)
JEFFERSON
(CONTROL)
AMBRIDGE
(CONTROL)
GRADE STANDARD
5 4 3 2 1 QUINTILES
0-20 21-40 41-60 61-80 81-100 PERCENTILES

Figure 1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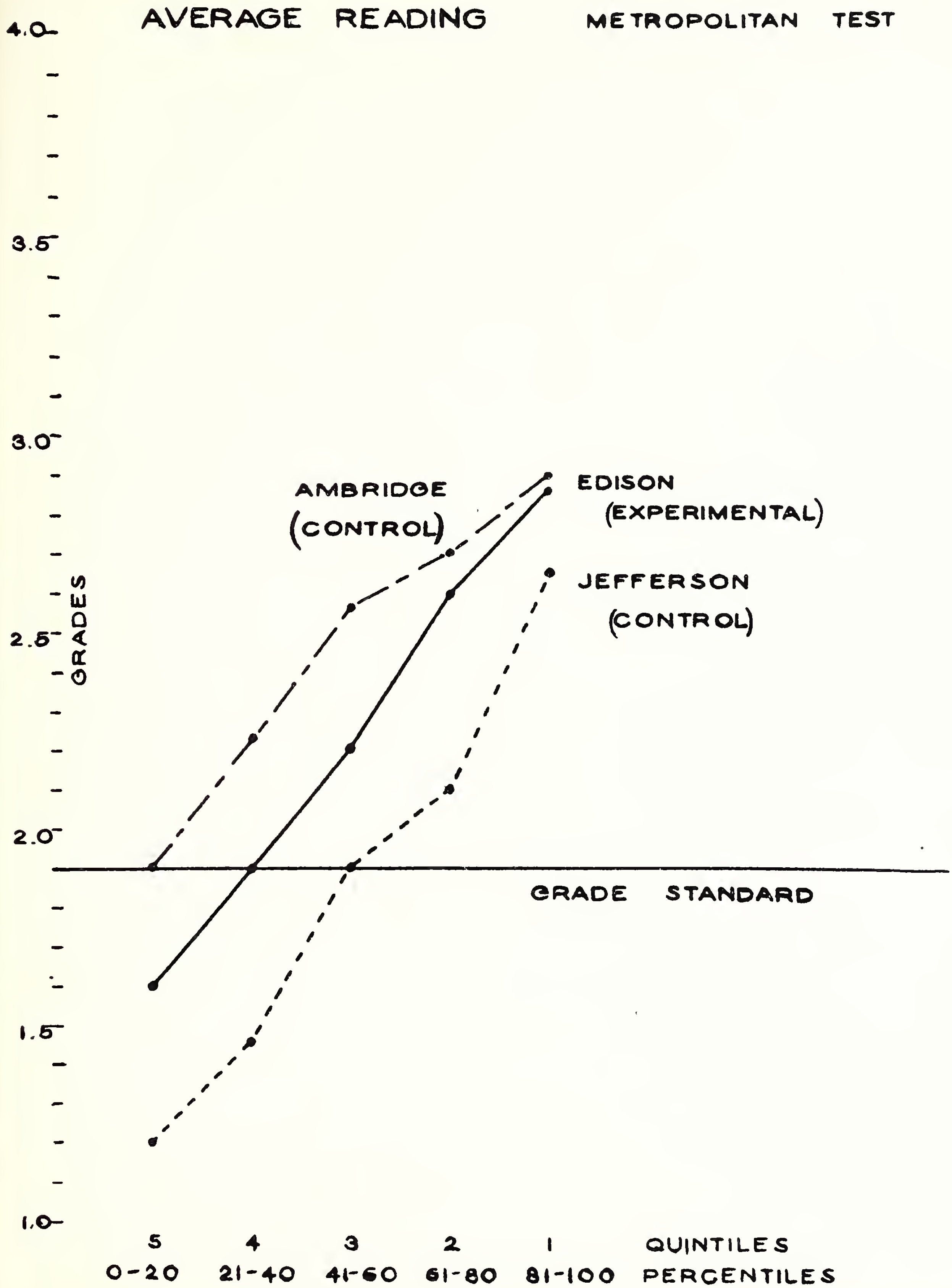
METROPOLITAN TEST
JUNE 1945
4.0
3.5
3.0
2.5
2.0
1.5
1.0
GRADES
EDISON
(EXPERIMENTAL)
AMBRIDGE
(CONTROL)
JEFFERSON
(CONTROL)
GRADE STANDARD
5 4 3 2 1 QUINTILES
0-20 21-40 41-60 61-80 81-100 PERCENTILES

Figure 2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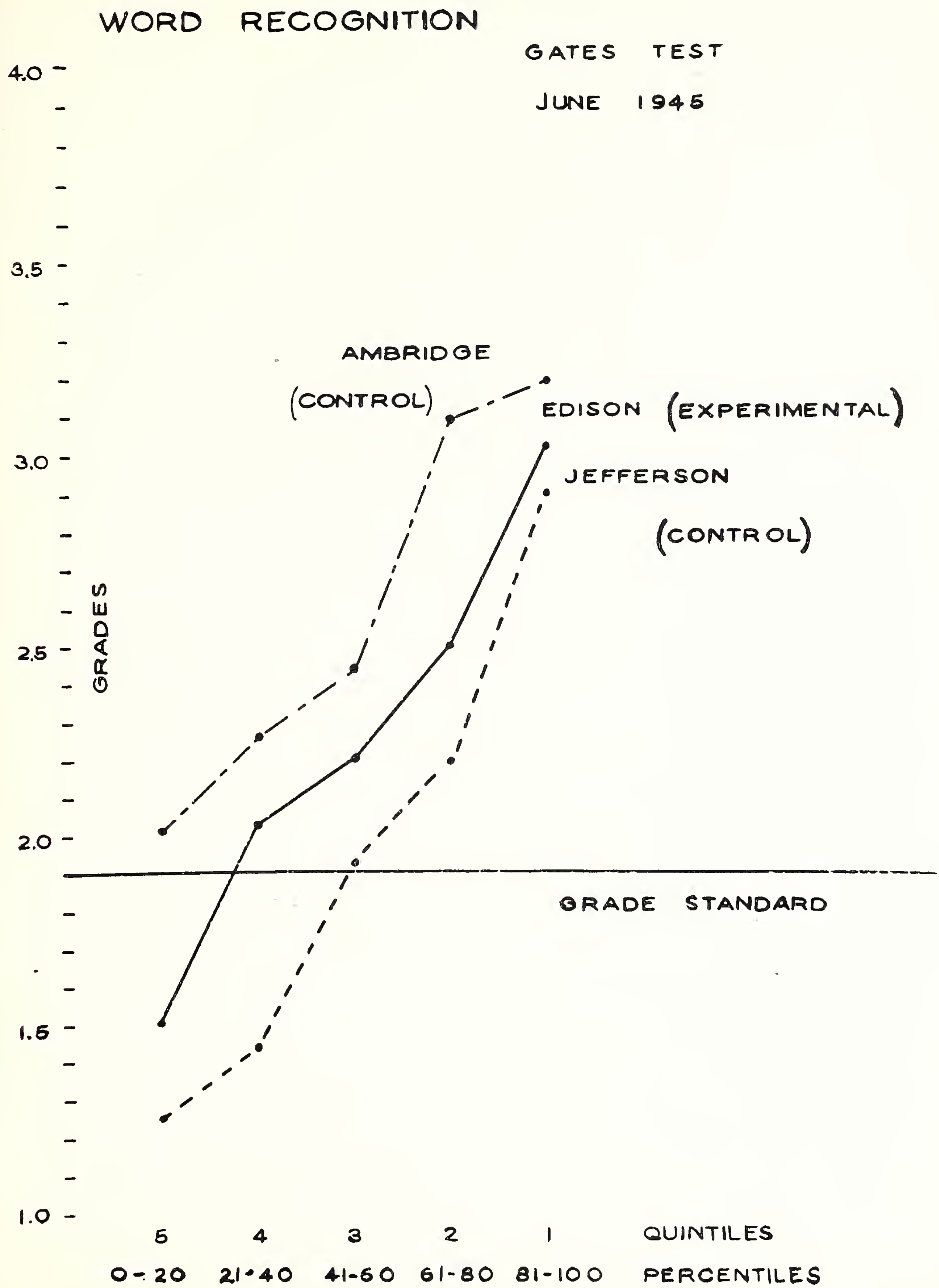
(CONTROL)
EDISON
(EXPERIMENTAL)
JEFFERSON
(CONTROL)
GRADE STANDARD
5 4 3 2 1 QUINTILES
0-20 21-40 41-60 61-80 81-100 PERCENTILES

Figure 3


WORD RECOGNITION
GATES TEST
JUNE 1945
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3.5
3.0
2.5
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GRADES
AMBRIDGE
(CONTROL)
EDISON (EXPERIMENTAL)
JEFFERSON
(CONTROL)
GRADE STANDARD
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4
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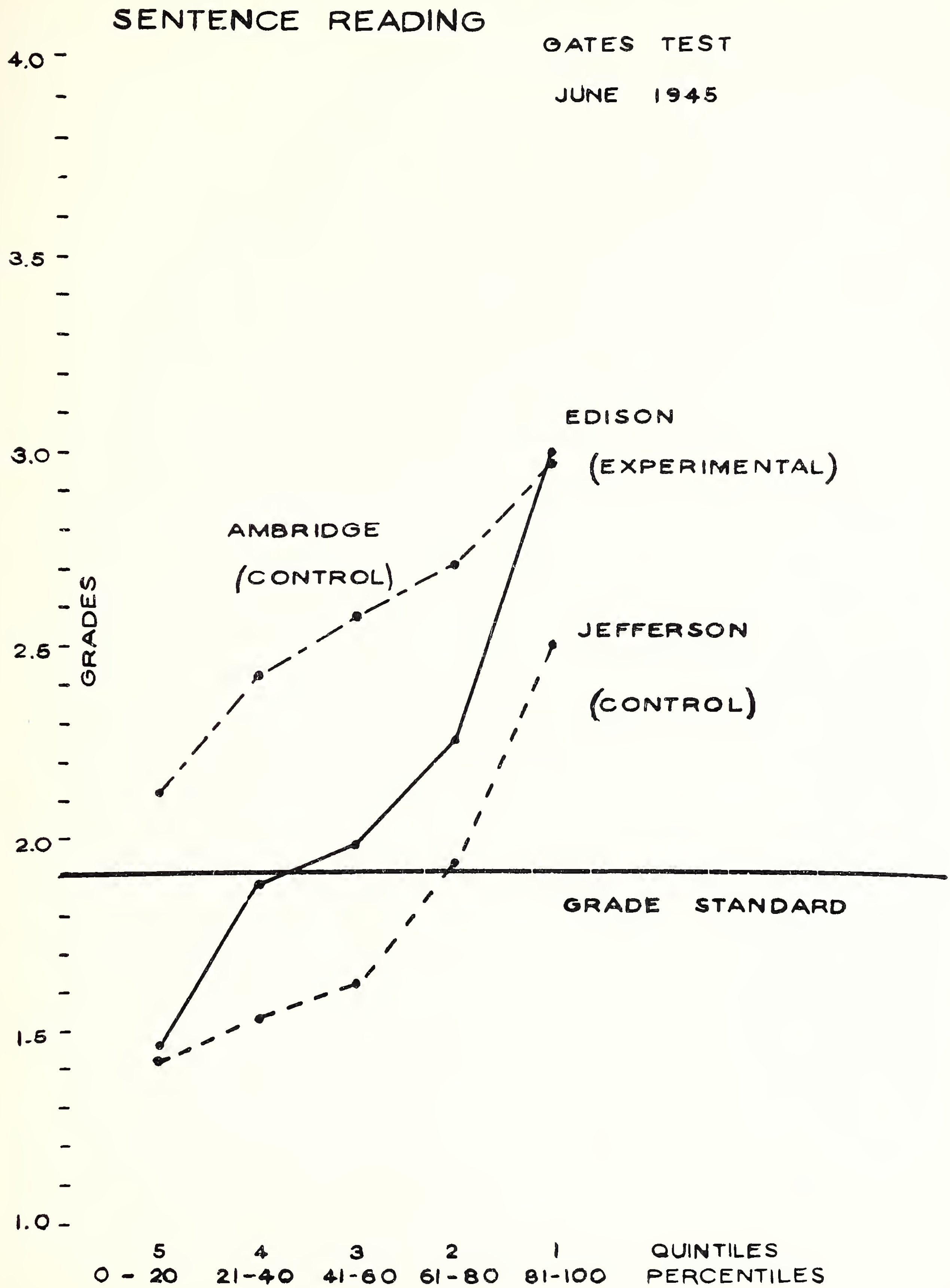
QUINTILES
0-20
21-40
41-60
61-80
81-100
PERCENTILES

Figure 4


SENTENCE READING
GATES TEST
JUNE 1945
4.0
3.5
3.0
2.5
2.0
1.5
1.0
GRADES
EDISON
(EXPERIMENTAL)
AMBRIDGE
(CONTROL)
JEFFERSON
(CONTROL)
GRADE STANDARD
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QUINTILES
0 - 20
21-40
41-60
61-80
81-100
PERCENTILES

Figure 5

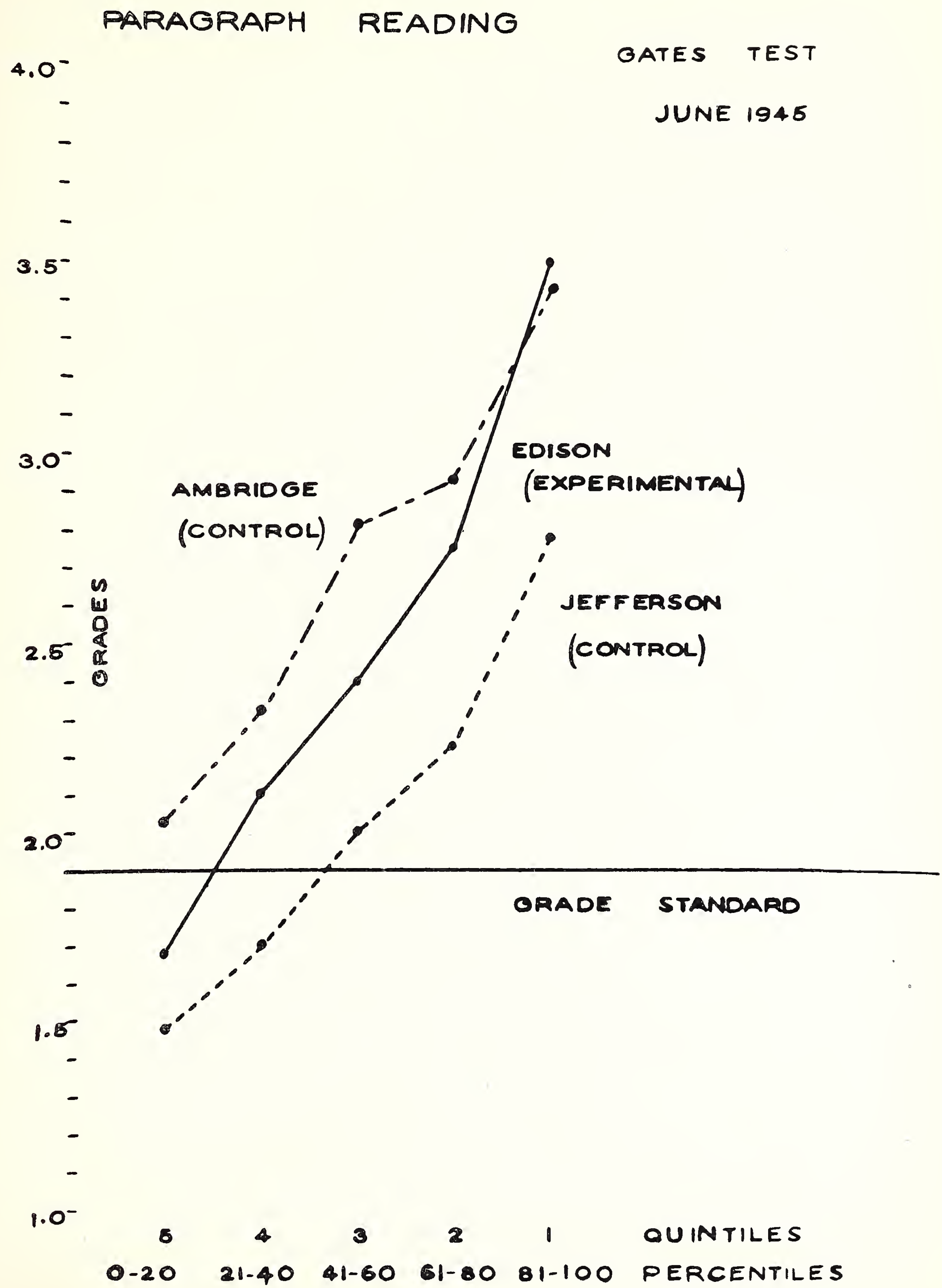
PARAGRAPH READING
GATES TEST
JUNE 1945
4.0
3.5
3.0
2.5
2.0
1.5
1.0
GRADES
AMBRIDGE
(CONTROL)
EDISON
(EXPERIMENTAL)
JEFFERSON
(CONTROL)
GRADE STANDARD
5 4 3 2 1 QUINTILES
0-20 21-40 41-60 61-80 81-100 PERCENTILES

Figure 6

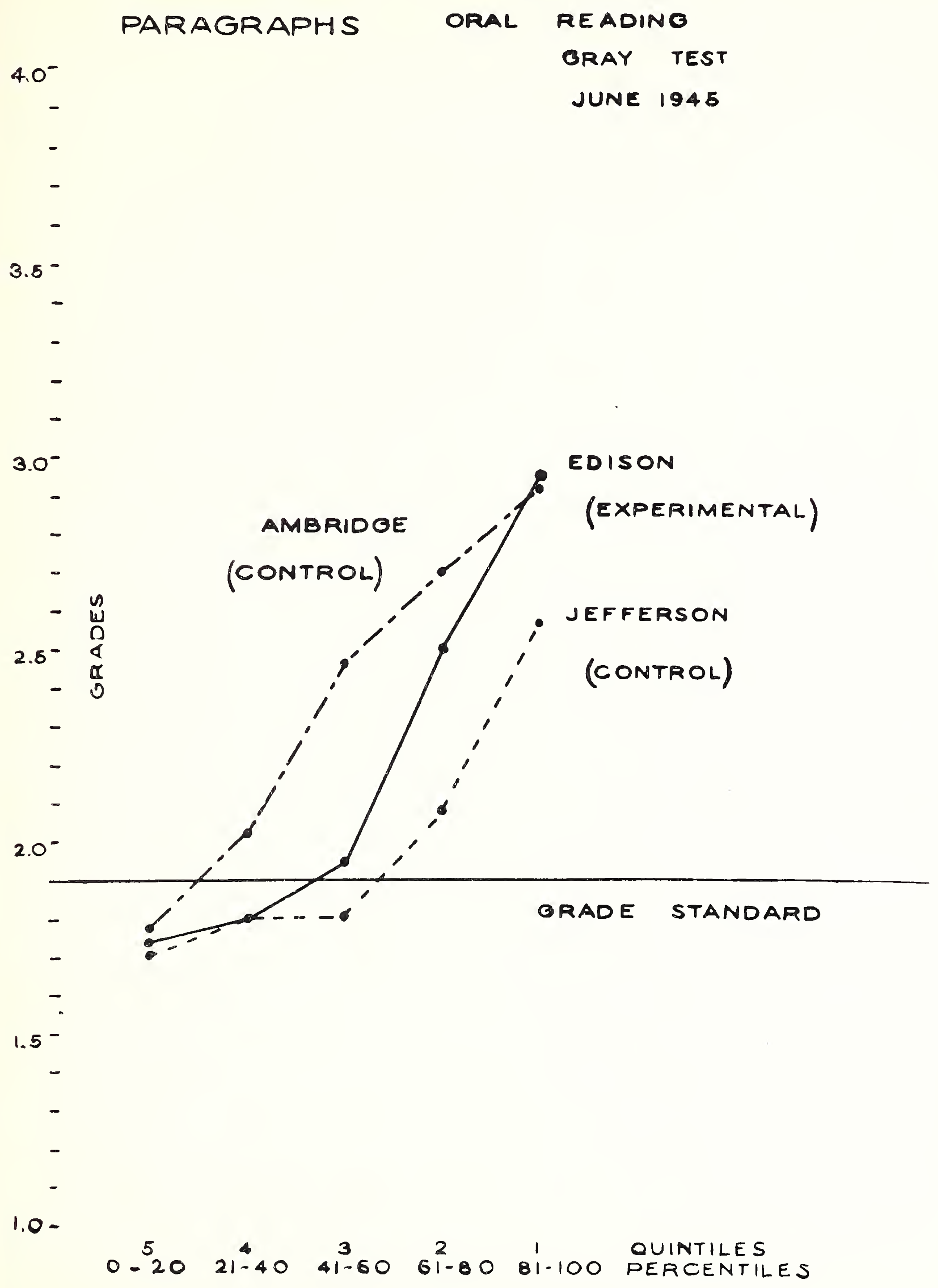
PARAGRAPHS
ORAL READING
GRAY TEST
JUNE 1945
4.0
3.5
3.0
2.5
2.0
1.5
1.0
GRADES
EDISON
(EXPERIMENTAL)
AMBRIDGE
(CONTROL)
JEFFERSON
(CONTROL)
GRADE STANDARD
5 4 3 2 1 QUINTILES
0-20 21-40 41-60 61-80 81-100 PERCENTILES

Figure 7

Psychological Optics
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OPTOMETRIC EXTENSION PROGRAM

THE CONCEPT OF FIGURE AND GROUND
(Part I)

December - 1945 Vol.6 No.2

A new fiscal year begins. This paper deals with a subject which could not have been written six years ago, partly because it would have been devoid of meaning to most optometrists and partly because the writer had, at that time, no very clear understanding of the theoretical basis of optometric diagnosis and training, and certainly no notion of how theory, fact and method from psychological optics could be made useful to the professional optometrist.

It is always difficult to chronicle the true historic sequence of events, particularly when many persons, living and dead, have contributed to those events. Nonetheless, things are being done, new tools being used, and results are being attained which have developed, in less than a decade, out of the theoretical and operational relations of O.E.P. optometry and experimental psychology. Skeffington and his 'gang' have dared to think of seeing as something more living and potential than a few unrelated facts of geometric optics or a defenseless neuro-physiology which transfers exact-copy 'images' on the two retinas to the dark continent of the brain cortex and there abandons them to a mythical 'perception', 'understanding' or 'memory'.

It is only natural that optometric thinking should go the same way advanced thinking has gone in other divisions of science. In psychology, for example, 'sensations', - elemental, non-analyzable mental processes, - were old and current as facts in speculative systems before there was such a thing as psychology. Was the sensation doctrine taken over almost without question by psychology? Yes. What is the present status of the doctrine? A closed chapter in the history of psychology. Dead. Why did it die? Simply because it never really lived; it could not hold against the ever increasing weight of evidence against it; its whole theoreticl foundation was unsound. As the late Professor Koffka once observed "how false the claim that a theory is nothing but a concise formulation of independent facts."

The history of science is a history of expanding concepts, of theory extended beyond the range of present sensory discrimination and tested and verified. Trite as it may sound, we likely enough do no more in predicting than to test the essential soundness of the original thinking, planning or postulation which led up to the guess. When theory changes, both old and new habits must change. How for example, can I subscribe to a 'deficit economy' in running my own small affairs and also adhere to the rigid, honest, industrious frugality taught me early in life? Or, how can I understand why a myope wears a concave lens when a concave lens makes things look smaller and farther away?

In previous papers it was shown that object vision is not a simple copying process; that even the simplest shape, consisting of but a few lines, demands for accurate perception and reproduction an elaborate process of sensory-cortical-motor changes. The essential thing about this process is that it attains a tolerable identity with the impression figure or shape by an involved process of field structuring or organization. This process was grossly over-simplified by the advocates of the 'sensation' doctrine.

There have been four or five ways of regarding the nature of this process. The view of (1) nativism holds that percepts, movements, etc., are controlled by neuromuscular mechanisms preestablished <u>ad hoc</u>. Visual space, pitch discrimination, acuity, etc. were fixed both by inbuilt limitations, both as to range and proficiency and little or nothing could be done to change them. (2) Empiricism held that such processes had

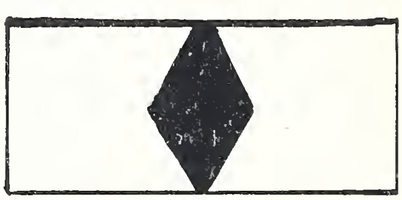
to be acquired by learning or training. A baby starts out as a blank page upon which the world indites itself, as best it can. Percepts and movements, accordingly, were determined by the residuals of past experiences, summated and abstracted and generalized into stable forms. (3) Configurationism or organicism or Gestalt theory held that all such percepts and movements are structural and functional organizations within extended wholes and never exist in local isolation. Field organization - i.e. how anything becomes a thing in visual space - depends upon the relative properties of local conditions. These relative properties are the paradigms of forces set up within a field by local conditions, and the distribution of such forces in pattern arrangements of various sorts are the determiners of forms and meanings. Parts exist only within constituent wholes and you get parts only by an artificial mode of analysis. (4) Motor theory agrees part way with all three previous views but also takes notable exceptions. It regards with favor most of the basic claims of Gestalt or configuration theory but insists that it must go at least one important step farther. It holds that all sensory and central or cortical processes are really preliminaries to the important consummatory effector processes; that mental life is movement, the backstroke from which is the principal means of the revision of function, by approximation and correction called learning.

There is finally what some have called an eclectic position - which stands everywhere and nowhere. It claims to formulate a theory taking only the 'good' parts of others. The result is usually a confused and inconsistent set of incompatibles which evidence laziness, immaturity or incompetence in thinking. The sensation doctrine was old before scientific psychology was born. It was taken over as most traditions are, and a long struggle ensued in the attempt to make it a useful working category. A sensation was defined as an elemental mental process, incapable of further analysis, and characterized by its own special attributes; quality, intensity, duration, extensity, protensity, attensity, etc. Complex percepts were aggregates of these units, held together in some un-understandable way by mere temporal contiguity.

Many American and foreign psychologists refused to accept such a doctrine. In the first decade of the present century a group of very competent men proposed a 'functional' point of view in opposition to sensationism. Clearly, they held, percepts are something more than mere collocations of independent sensations; interrelations must not be disregarded: such things as contrast effects are real things. I am tempted to apologize for so brief a sketch as the foregoing, but it is entered here as a necessary preliminary to understand the significance of a discovery, made in 1915, by Edgar Rubin, a Danish psychologist.

Rubin was the first to point out that when we see a simple object within the visual field we see it as a figure on a ground. The figure is the thing and the ground is the framework, the stage-setting, or the surface upon or within which the thing is seen. A thing to be a thing must have boundaries, contours. Rubin showed that contour in perception is a one-sided function.

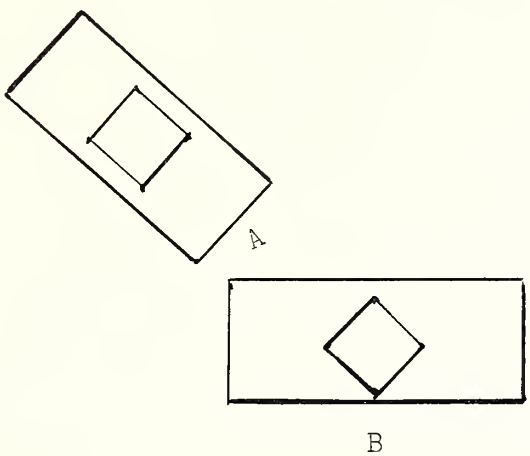
Look at the simple figure in the following diagram:

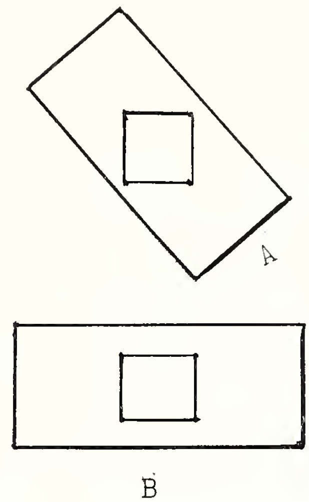


The diamond lies within and upon the ground of the oblong, and also upon the secondary ground of the page. Rubin showed that the contour of the figure shapes its inside but not its outside: that contour has a one-sided function. It segregates the figure from the surrounding ground. Contours which shape the figure do not shape the ground. If the ground has shape, it owes this to forces other than those which organize the figure upon the ground.

Note that the figure lies on the ground; it is nearer to the observer and the ground is continuous back of the figure,

although not directly seen. Any figure depends for its properties (size, shape, position, and to an extent brightness and color) upon the characteristics of the ground on which it appears. This rule is general and applies very widely. Two experiments throw further light upon this problem. Hartmann (1923) showed that the square is easier to see than the same square turned in such position that it is named a diamond because the diamond has a greater flicker limen (critical fusion frequency) than the square.





Kopfermann (1930) showed that in the above figure B is seen as a diamond and A as a square. The orientation of the two figures is the same. Hence orientation of the figure is not the absolute determinant of its shape, but relation to the frame or ground is a very instrumental factor. Space enclosed in two circles, one 23 and one 25 millimeters in diameter, and viewed in a stereoscope at the correct decentration for good fusion will look 'different' from the same white cardboard which is dually at one and the same time a surface in front enclosed in the single circle and the continuous ground in front of which it lies.

In the above figure A is more ambiguous and unstable than B. The figure depends, in this simple case on the larger ground of the page, the more immediate ground of the oblong, and the simplicity of the resulting figure. Figure and ground differ from one another because each has different properties, behaves differently, interrelates differently as local conditions are changed. Ground, the "unseen" portion of the visual field yet contributes greatly and importantly to figure formation. Ground is simpler, more coherent and homogeneous and less stable than figure. Figure is held together by stronger forces than ground.

Next month we shall continue with further discussion of the dynamic interrelations of figure and ground in field structuring.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part II)

January - 1946 Vol.6 No.3

It is strongly urged that you re-read the previous paper (Vol.6, No.2) before you begin this one. Rubin was among the earliest to point out that the forms we see, even the simplest common objects, achieve form by an intricate process of the structuring of the whole visual field. Structuring means a redistribution of forces.

If it could be shown that the processes of field structuring are not different from other known processes in nature where forces interact and approach a more stable equilibrium, such demonstration would mark a forward step in theory, the consequences of which can hardly be overestimated. It would at once place the perceiving of forms and executant manipulatory acts in one and the same category. It would have far reaching effects upon certain measurement procedures in vision, at present highly artificialized by assumptions which disregard, for example, the unnoticed but highly important component, the grounds. The instant a figure emerges from a ground or is set upon a ground, its boundaries tighten the structure with those limits. The figure will tend to show an inertia effect. It will resist distortion (form-constancy), and limits will be set to the amount and kind of changes which can be made in it so long as the ground remains constant.

It will be shown a bit later that the figure-ground relation is an unstable equilibrium. It is never static. The apparent paradox of the relation is that in spite of the constant rivalry or antagonism of F and G, it is out of this destructive trend that constructive forms are achieved. We may safely set down, therefore, that even the simplest forms are dynamic patterns or masses of energy. They grow and die away, come and go according to laws well known in mathematics and physics.

Now if this is true (and who can dispute it?) it must be evident that 'image' formation at the retina, in the brain, or anywhere in nature is never a direct copying process. The essence of such a view is passivity of the mechanism; in reality the essence of the whole process from beginning to end is activity. Again and again evidences appear which force us to realize the essential sameness of the processes of perceiving and acting. And if you will carry about with you this concept of figure-ground structuring and test it by applying it, you will find surprising numbers of instances of its important operation in nature.

Last week I visited late one afternoon a colleague who is an ardent amateur musician. Professionally a lawyer and certified public accountant. Sitting at his piano he played a single cord. He asked me how I liked it. I asked him if he really wanted my judgment; it was a vile sounding dissonance. He then played a half dozen majestically beautiful cords, the last of which in time was our old friend above. Now everything sounded perfect! With a chuckle he informed me the cords were parts of a composition by a world-famous composer.

Tones or compound sounds can have shapes, too. Just as the little squares can be made into diamonds by changing the ground in the figures of last month's paper, so cords depend for their properties in part at least upon the position they occupy in a temporal series. Talk about musical form is thus not artistic palaver. It is something real. Something important. Something old, yet very new. For we are only dimly aware of the reaches and of the controls we may manage in the process of the achievement of form.

A little reflection will show how this general principle applies in tachistoscopic work. And if you have ever tried to make stereo pictures, you will appreciate the fact that several years ago I made a fine set of 11 x 14 stereo prints of grounds (landscapes, etc.) on which I tried to paste several types of cut-out figures, without

success The forces which block the entry of some figures as belonging to or in some grounds are real thing, let no one deceive you on that point. Let the skeptic try it himself.

Many readers of this paper have seen and used my series of size-constancy stereograms These are stereo photographs of real objects (white cardboard squares) in a real ground. When the 6, 12, or 24 meter target is viewed in a suitable stereo instrument and its apparent size measured by the method of equivalents, there is rarely an exception to the observation that the same target is seen smaller at near point than at far point. Also if we give a microstructure to the surface of the targets the effect is still stronger. Such findings are certainly at variance with what we might expect from geometric or physiological optics, or from Emmert's "law."

Let us regard these findings in another way. The change from far to near point does not change figure and ground equally. And as we have pointed out, the increase in the apparent size of the ground at near, although unnoticed, should be accompanied by an increase in the centripetal forces within the figure, which should then be seen smaller than the logical or calculated size-distance relation should give This is precisely what happens in experience and if the above reasoning is sound our method and apparatus for size-constancy measurement ceases to be a laboratory curiosity and becomes a direct measure of field forces within the optical sector of the central nervous system (particularly the retina and brain). More, it is a challenge to the creative thinking of every optometrist and ophthalmologist whose job it is to assay the functional vision of Mr. Joseph Doaks, the fellow to whom the lady in white says: "Next, the Doctor will see you now."

In young infants, Ling (Journal Genetic Psychology, 1942, 61, 264) states that one of her most significant findings was that "the infant, even after he has arrived at the stage of Perfectly Sustained Fixation, continues to respond differently to the stimulus disk when it is within a close range (within one foot) than when it is farther away."

The measurement and interpretation of acuity, fusion, phorias, in fact almost every finding, must be regarded as a special case of the general principle we are considering, namely, the dynamics of figure formation within or upon one or more grounds.

Likewise it is important for us first to consider the operational properties of grounds - fore, mid and back - and those of the enclosed figures so that we may then pass to a consideration of the known laws and principles which describe the mechanism of structuring or organization within the field.

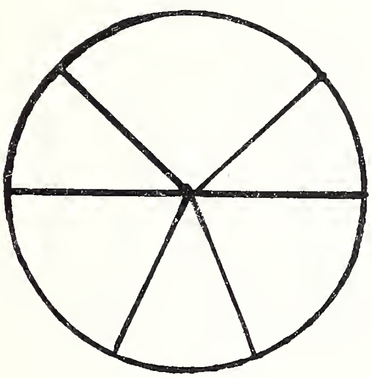
We shall begin with the examination of a single shape first. In the simple case will be found the working of the basic principles, true also of more complex field structures.

At this point I should like you to recall a basic fact of the retino - cortical organization. Macular and foveal sharp discrimination of boundaries which give shape or form to things, is surrounded by a perimacular and peripheral region in which each degree of decentration is marked by a rapid loss of resolution. The average solid angle in which forms can be seen is not far in the untrained from 20 degrees horizontal and about 16 degrees to 18 degrees vertical, centered of course in the fovea. It should be recalled that resolution diminishes rapidly before the form limit is reached. At 6 degrees on either side of the line of sight acuity has lost fully 75%, and thenceforth quickly drops in a few degrees to such a point as to be useless for effective seeing. As a matter of fact a 50% reduction is a serious resolution loss which in most cases may not only leave form unhampered, but by a process to be detailed later on, may actually enhance it. Thus the visual apparatus itself is so constituted as to favor the casting of the whole retinal pattern of excitation into what has been called a center and a fringe, focus and margin, and one German psychologist used the terms blickpunkt and blickfeld. To those interested in the moot question of the projection of the macula in the cortex, it is noteworthy in our discussion that G. J. Van Heuven, in his Amsterdam dissertation of 1929 showed that in the brain the macula is projected in wide diffusion throughout cytoarchitectural regions 17, 18 and 19, whereas the entire

periphery is restricted to an overlapping core of very limited dispersion. (See Fulton, J. F. Physiology of the Nervous System, Oxford, 2d Ed. 1943, p. 329).

It is enough for us to realize as Detwiler (Vertebrate Photoreceptors, McMillan, N. Y., 1943) has shown that in the evolution of the mammalian eye the above structural design was not always obtained. In birds the foveas, for example, are ditch-type and extend practically the whole circumference of the globe. In a later paper we shall carry the anatomical and physical basis of form vision farther.

Let us look now at a simple diagram:



If one fixates the center either 3 small or 3 large sectors may be seen. These will reverse. Graham (1929) varied the size of the small sectors from 10 degrees to 60 degrees by 10 degree steps. He found that the smaller the sectors the more stable they were as figures. Ten degree angles dominated in reversals 1 1/2 times as long as equal sized sectors. When figure and ground are of equal brightness, Graham found that area was the most important factor in perception.

Rubin (1921) stated the law as follows: If of two homogeneous differently colored fields the one is noticeably larger than the other and surrounds the other, then there is an overwhelming probability that the small inclosed field is perceived as figure.

Ground is simpler, more homogenous. Figure is more solid (thing-like) while ground is more loose (stuff-like). Figure is stronger that is more resistent to distortion or to the intrusion of a second figure in the same field and is held together within its boundaries by stronger forces than ground. Ground provides masses of color, brightness, area, etc. out of which portions become salient by the creation of boundaries.

If a figure similar to the above is made by pasting green sectors on a gray ground, when reversal takes place the green appears darker, less saturated and the gray becomes distinctly pink. Color is stronger as figure than as ground.

In every scene we see the factors of size, distance, brightness, color, relative position, motion etc., are always at work. Some oppose and some enhance one another. The final resultant is an algebraic kind of resolution or summation of forces within the field. Whatever form emerges from the ground depends upon the complex interaction of these forces.

Within the visual apparatus the influence of a change in one portion of the field can act remotely to redistribute the entire field. If the field is complex - as are all 'simple' visual experiences - and contain more than a single saliency, a change in one locus is capable of changing, for example, the relative positions of two apparently constantly separated sub-figures in the field. The practical bearing of this sort of theory upon the problem of space projections or phorias, is at once apparent. Measurements of such type are never static. They represent phases of a dynamic system within larger enclosing systems. To maintain, as one teacher of optometry claims, in a recent paper, that such mechanisms or functions are "innate" and hence not susceptible to practice effects is, to say the least, surprising. Such position is difficult or impossible to defend. The characteristic of field organization is its susceptibility to transformation through proper training. The hope and promise for future research along these lines is greater than any other I know. No province has been more important in psychological optics in helping us win the war than in the field of perception and learning. No province has shown greater developments in the last two decades.

Next month we shall continue with a study of the dynamics of figure-ground organization.

Psychological Optics

—BY—

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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part III)

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All objects seen within the visual field attain form only as contours or boundaries are established. Several facts indicate how boundaries are set up. Rubin first pointed out that when organization proceeds within the visual field and the larger enclosing space frames the smaller salient patch occupied by an object, the enclosed space becomes figure and the enclosing space the ground. Kohler and others have shown that the whole field begins its process of structuring with the physically simple and necessary formation of a potential gradient. The enclosed figure is the region of the maximum potential or activity. A year ago in these papers I tried to show that in biology gradients of metabolism or energy distribution may be regarded as the mechanism for the establishment of dominance and isolation, the primary beginning of structuring by dynamic principle to create the individual or unified organism. Fields are at first relatively uniform energy distributions. This state cannot long be maintained, if as is always the case, energy changes are constantly taking place within enclosing or adjacent fields.

In the case of Rubin's law the enclosed figure should be regarded not as some object out there in space, but should be thought of as existing out there because of the operation of Stratton's principle of <u>external reference</u>. We project the cortical-motor energy pattern of impression from the sense organ to that spatial position which checks, in phenomenal experience, with the consequences of manipulation and conventionalized biological and psychological experience.

In the cortex the field of excitation at any instant <u>represents</u> the retinae. The aligning of the fovea to receive that portion of the ray sheaf which corresponds to the figure object isomorphically can be regarded as the focus of the inward projected energy gradient. Perimacular and peripheral areas will stand as regions of low energy. But the representation must always be regarded as molar rather than molecular. I can, for example, occlude my left eye as I face the red brick wall of a building. My macula has good color vision, my perimacular regions are partially color blind and my periphery is totally (or almost totally) color blind. But I see a uniformly red wall nonetheless. We must, it seems, exercise the right to include in visual theory as in other biological and psychological provinces, the principle of emergents. We must postulate that the phenomenal reality of perceptual filling is in its own right ample proof of the impossibility of looking for and finding support of the constancy hypothesis. We never see what is out there. The final phenomenal field is a construct whose determinants are not derivable from the local and isolated physical events at the moment. Elsewhere again in these papers I have tried to show that perception is always essentially a process which runs a course in time and that nothing is gained in our feeble efforts to describe it by either a willful or unwitting oversimplification.

The figural object becomes the cortical object - i.e., a region of or mass of bounded energy. At the boundary, from without, the forces of the enclosing ground are different from the forces of the enclosed or internal figure. The boundary is a boundary only of the enclosed figure. As the ground is made larger the inner forces of figure become more compact. Their direction is centripetal and figure becomes denser, 'harder,' more stable and resistent to distortion. Any and all properties of figure objects depend only in part upon the intrinsic properties of that portion of the total field which represents figure. Changes in the ground, the relatively unnoticed part of the visual field, can produce large changes in figure. This fact, easy to demonstrate, has far-reaching and important consequences for visual science.

I predict that within a few years the most important developments in visual diagnosis and training in a century will be produced by research aimed at the set of problems arising within this dynamic perceptual field. In fact the work of Kohler and Wallach may be cited as testimony, along with the earlier works of Wertheimer, Wulf, Fuchs, Gelb, Metzger, and others, that many strikingly important developments are already here.

Some critics will say, "How do you know the vectors of the figural portion of the cortical field?" Quite frankly the answer is that no one now does know. Thus far it is an honest and sincere attempt to construct a theory which accords with phenomenal reality better than any of the existing theories do at present. Years before the achievement of the mass-energy chain reaction in U-235 and its derivatives, Professor Einstein wrote a very simple theoretical equation. Upon the basis of pure theory science proceeds to discovery and demonstration of how things work and can be made to work *our way* in nature. The case in reality is not without considerable experimental verification of many points. The late Professor Max Wertheimer published, in 1923,* the first description of his experiments leading to the formulation of his laws of organization in perceptual forms. Wertheimer noted that what he saw on looking out his window was not an aggregate of unrelated shapes and brightnesses; not either a "mode of organization lying solely within my own pleasure." What he saw was "the arrangement and division which is given there before me" - and by special effort and self-imposed instruction he was able to *discover*, "that part of a window sash and part of a bare branch together compose an *N*." Even simple patterns of dots on an undifferentiated ground were seen to combine in some sort of "spontaneous" or "natural" mode of grouping. "Any other arrangement, even if it can be achieved, is artificial and difficult to maintain." Do such "natural" groupings follow discoverable laws or principle?

He examined a row of dots:

. .   . .

These are seen as 1-2, 3-4, 5-6. They can be seen as 1, 2 3, 4, 5-6, etc. If the first grouping is used, the whole row can be seen patterned in this manner. If the second is used it is next to impossible. The process is disjunctive. After trying out many patterns he saw that "that form of grouping is the most natural which involves the smallest interval." This he called the Factor of *Proximity*. In the visual field any aggregate of objects becomes figural as the grouping becomes compact or proximal enough. *Position*, in space and time, is thus a first important factor in figure-ground structuring.

Wertheimer's second principle is really a corollary of the first and yet introduces a new factor: The Factor of *Similarity*. It is "the tendency of like parts to band together." If in a row of evenly spaced dots 1-2 are black and 3-4 red and so on, proximity is constant but the grouping by two's is this factor of similarity. Both similarity and dissimilarity in varying degrees operate to determine experienced form. If you want to hide in a forest make yourself look like a tree - and stand still. Note that this factor may operate to produce grouping or if the figure object is made similar enough and homogeneous with the ground to abolish grouping. If you can agree with everything up to this point you can see, for example, a possible mechanism for amblyopia, *and* the line of attack for its control.

Wertheimer pointed out further that Proximity and Similarity may be set in competition or may aid and assist each other. From this fact their relative strengths can be measured. The third law is called the Factor of Uniform Density or Common Fate. If in a row of dots like -

. . .   .

7-8-9 and 10-11-12 are shifted up or down one space not much is changed for the observer. But if 3-4, 5, etc., are shifted it may either form a new grouping pattern or be seen as a confused or awkward arrangement. A slight shift in the position of one or more sub-groups may thus destory the unity, coherence, ease of perception of a

*Unterschungen zur Lehre von der Gestalt, II, Psychol. Forsch., 1923, 4, 301-350. See also Ellis, W.D., Source Book of Gestalt Psychology, 1938, pp. 71-94.

total pattern. This fact is not without practical bearings.

The fourth law may be called Optimal Perceptual Levels (Pragnanzstufen). Again taking a series of rows of dots -

.. ..

The 1, 3, 5 etc., dots are constant and 2, 4, 6, etc., are varied so that the distances between 1 and 2, and 2 and 3 are varied. Wertheimer used the following separations:

	Separations	
Row	Dots	Spaces
1	2	20
2	5	17
3	8	14
4	11	11
5	14	8
6	17	5
7	20	2

Each row is seen individually. Rows 1, 4 and 7 gave three discriminations different from the intervening rows. As dot 2 is varied the separations are not all equal psychologically. Intermediates approximate or deviate from certain of the preferred order, levels or positions.

The fifth Factor or Law was called Objective Set. If all the rows are shown simultaneously to the observer and he passes from row 1 to 7, or from 7 to 1, "the original grouping in each case tends to maintain itself even beyond the middle of the row." Row 3, for example, will be seen differently if preceded by 1 and 2 or 6, 5, and 4.

In Factor Six, the Factor of Direction, it was shown that organization in the perceptual field cannot be accounted for by spatial proximity alone. Dots shaped like this:

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            .
            .
            .
            .
. . . . . . . .
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are seen as a horizontal and a vertical line rather than as two right angle figures. Wertheimer points out that good continuation, inner coherence, unity in a pattern arise from the interplay of forces within the pattern. Simplicity or complication is a property of the whole organized mass, not of separate parts.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

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FIGURE AND GROUND
(Part IV)

The seventh of Wertheimer's principles describing the factors of organization in the perception of figural unities is closure. When boundaries are established for any object within the visual field, the forces within the enclosed (thing) area are disposed differently from those within the enclosing space (ground). The ground, however, exerts a positive and determinative influence on the size, position, shape, distance, brightness, motion, etc. of the figural object. In cases of acute retinitis where only a small foveal area is active and unaffected, blurring and failure to perceive simple forms is a frequent concomitant. Yet in hysterical peripheral anopsia the active field may be the same size with central vision unimpaired. The factors which determine central resolution must be not merely the size or functional integrity of the central macular area, but must lie in the particular influence of ground upon figure.

Within a homogeneous ground a figure tends to become as "good," as stable, as simple, as unitary, as resistent to distortion as circumstances will permit. This is the thing meant by closure. Obviously changes in figure (size, contour or shape, brightness, relations to other portions of the total field, etc.) may either further or reduce the course of the process. For example the addition or removal of a single tree, or the figure of a man standing or walking away, in a picture may profoundly alter its character, its impression value, its "composition." In drawing, painting and photography this fact is well known, but not too well understood. The reason is clear. We deal, in such cases, with the whole complex set of problems of perceptual organization. If we break the organic, internal unity of a visual pattern, we instigate tensions within the field which are followed at once by disjunction. Closure moves in the negative direction. Understanding, smoothness, stability, unity of perception is gone - to be replaced by confusion, fog, an unrelated and comparatively meaningless plurality of things. Perception becomes effortful, awkward, and leads everywhere and nowhere. Closure is the trend toward smoothness, simplicity, stability, law and order. But it is an approach to a dynamic equilibrium. The forces active in shaping its course may be many and diverse. They may add arithmetically or algebraically.

Simple examples of closure in perception may be given. If the apex of an equilateral triangle is sheared off and the incomplete figure is shown tachistoscopically for 10 milliseconds, and the observer draws or describes what he saw, the probability is high that he will draw the complete triangle. Why does he not draw two horizontal lines or "handles" from the stump ends of the legs of the triangle? Such a figure is more difficult to see; runs counter to the fact that the perceptual grasp of the concept triangle has been built by movements of drawing; tracing, nailing together three pieces, etc. The external stimulus may be regarded as serving merely to set in motion forces already predisposed from prior art to complete the formation (phenomenally) of the triangle. Perceptual filling is another name for this process. It is a phase of the age-old part-whole problem: the problem of the one and the many. To William James is attributed the statement that "everything coheres that can cohere; nothing separates expect what must." Closure is the trend toward this state of best possible internal - external relations which circumstances will permit.

If we show tachistoscopically the numbers arranged as they are on the face of your watch, but with one number, say the 4, displaced out toward the rim, the perceiver will in most instances see and reproduce it in its correct position. Spatial position, therefore, depends in part upon the other members and their relative positions to the displaced member. Closure embraces the

aggregate of divers forces within the field which make for symmetry, unity, coherence. A further example, a simple form of stroboscope is a metal drum with evenly space slits in its sides through which a strip of paper mounted inside may be viewed. On this strip we mount figures in successive positions. When the drum is revolved at an appropriate speed we see apparent movement. If we place single black dots in the positions of our watch numbers on rotation we see a single black dot moving about in a circle. If now we again displace the 4, or any number, there is no jump or break. Only the same smooth motion. The principle of closure applies here too.

If an ambiguous or indifferent pattern is seen, what determines the segregation and organization within the perceptual field? Numbers shown tachistoscopically often furnish examples. I once showed this 13 digit number to Salo Finkelstein: 5, 714, 923, 937, 415. I have added the commas because always Finkelstein grouped in threes from right to left. The exposure was brief - about 0.3 seconds. His reproduction was instantaneous and perfect. He reported that "that one was especially easy," because he saw 1942 (Columbus)3937 (inches in a meter) 415 (the number of Professor Renshaw's office) and all he had to do was to remember the 57! (He never heard of Mr. Heinz!) How much of this is ex post facto is difficult to say. It does not withstanding illustrate the fact that segregation and disembedding may transcend or violate 'natural' grouping divisions. It is organization by reduction through closure that the length and difficulty of the 13 digit number was substantially reduced.

In other instances certain number patterns "just go together" while others remain mere aggregates of single digits. The supporting frames of reference are highly individualized and utterly unpredictable. But there is abundant evidence of their presence and also of their active agency in shaping the final course and consummation in perception.

Closure, along with the six preceeding principles, is a very practical thing. Take far point acuity and its measurement for example. If rivalry is introduced anywhere eccentric to the line of regard, it sets up a tension gradient and the stage is set for disjunction. The target may then change its phenomenal size, its relative position, its sharpness of contour, its index of resolution. Those familiar with studies of acuity in hemianopsia where pseudofoveae have been developed, know that the new functional fovea is not anatomically determined; that resolution is better from a small E nearer the center and for a larger E farther toward the periphery; and that if the larger E is now placed nearer the center, it blurs; and that if specific parts of the E are fixated they may suppress and disappear. The seeing of a "simple" shape is never a simple process visually. There is abundant food for serious thought here. There is also a crying need for extensive, careful and painstaking research.

The eighth principle which determines formal organization is practice, training or habit - a factor of great potency. In spite of the fact that Wertheimer published in 1923 and that laboratory and clinical evidence of the transforming power of this factor has grown year by year, two recent papers, one in a leading ophthalmological journal and one, an editorial, in an optometric journal both conclude that Wertheimer's eighth law is untrue, i.e. that visual training is ineffective and hence it must follow that all visual functions are anatomically and physiologically fixed. Let us pass the question of the competency of the supporting evidence offered to substantiate such assertions. Let us simply say that the existence of a principle in natural processes is questioned as to its existence.

Habit, set, attitude, temperament, instruction, training are factors which determine figure - ground structuring. Let us cite a few simple examples. The late Professor Kurt Koffka often showed a class of students the figure below on the screen for about 1/2 second. Half the class were instructed to look for something white and half for something black, and draw it.

Those who saw the black figures T did not see the white flower designs, only the T's

set upon a weak and undifferentiated white ground.

Professor F. C. Bartlett, in his book, Remembering, cites abundant evidence to show that if the perceiver is pessimistic, realistic or matter-of-fact, or if he is extroversive, imaginative, the elaboration or restriction of detail in his reports will follow this temperamental pattern. In Africa his studies of primitive peoples showed that tribes whose lives were bound up with the care and possession of cattle built their basic perceptual concepts in these terms. A young soldier from the mountains of the Pacific Northwest told me he spent a year in New England in a virtual claustrophobia - hemmed in constantly by the smallness of the spaces.

Set your observer to see a few tachistoscopic exposures of 8 digit numbers and without warning show him a 6 or a 10 and he complains at once that the numbers are blurred, that something was wrong, but he will usually reproduce 8 digits. He will report nothing unusual about adding two to the six, or omitting two from the ten. His 'trouble' is ascribed to something other than the incompatibility of his set or frame of reference and the presented material. Most of our semantic troubles with languages arise out of the fact that what a pattern of words or sentences means to me or to you depends so largely upon this important factor. Courts are kept busy trying to tell what the lawmakers mean by a particular phraseology. The "iceberg" theory - so called - holds that a large fraction of every percept is determined by the unconscious, non-localizable, often non-verbalizable determinants that have been built in as after-effects through use, training, habit.

Not only in vision but in other sense modalities a laboratory commonplace is the positive and negative time error. If a solution is tasted, and this is followed too soon by another, the qualities or intensity of the second may be materially changed. In sound, a succession of harmonic chords may end with one which by itself would sound dissonant - but it does not because of its serial position. Examples could be multiplied. Habit, set, expectation, learning, training, these are powerful factors in field organization. They operate simultaneously with the other factors we have presented from the work of Rubin, Wertheimer, Wulf, Fuchs, Bartlett, Purdy, Mussatti and others. To assert that such factors are without force or agency in seeing is absurd. The penalty of such talk should be one year at hard labor in the laboratory. The real scientific problem is not "can sensory - cerebromotor functions be transformed by training?" but how can this be done most effectively and what are the limits. Next month we shall continue our discussion of figure-ground organization.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part V)

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The ninth principle of field structuring in perception deals with the factors of homogeneity and inhomogeneity. Any object to attain the status of figure on a ground must be segregated from the ground by contour lines sufficiently sharp so that the internal forces give coherence and unity to the figure object. The ground is always seen as a uniform and unbroken extent even behind the figure. In the pair of spilt stereograms (VT-1 Series, No. 5) with diagonal rivalry lines supporting two circular figure objects the ground may be observed to move up or down vertically with no change in the figure. If the entire pattern is seen as figure, rivalry may be observed. If only the circles are seen in third degree fusion rivalry is immediately abolished in the ground. We conclude, therefore, that rivalry is an essential characteristic of the figure experience. Likewise we see at once the diagnostic significance of the use of this type of target. The myope, for example, with weak or low capacity for segregation and figure aggregation will characteristically show anomalous projection (lateral phoria), low rivalry rate, reduced stereopsis level, slow fusion and limited range, poor break and recovery limits. Small wonder that frequently he carries his near point problem out and blurs or doubles at distance.

Brightness differences contribute greatly to figure segregation from the otherwise homogeneous ground. If the total illumination level is gradually reduced contrasts are lessened and eventually if the reduction is sufficient all figure portions of a picture return to the undifferentiated status of the ground. This is the reason positive transparencies are superior as targets to prints seen by reflected light. Figure objects are more sharply etched because contrasts are enhanced, boundaries sharpened. Intensity thus is an important factor in quality. This combination of factors, at present, is an almost unused function in visual diagnosis and training. It must be a guiding principle for the maker of test and training materials. If color is added to the objects the figural strength is enhanced. It should be recalled, however, that we have shown in previous papers that color and form are reciprocally related; also that brightness and color contrasts are antagonistic. Color contrast is at its maximum when brightness contrast is minimal.

Size, likewise, is an important factor in the attainment of the figure-ground structure. The principle of Optimum Levels (Prägnanzstufen) previously discussed operates simultaneously with the size-constancy trend. Phenomenal size, therefore, may give direct indication of the total operational resolution of all the factors which are combining to produce the final level of the judgment classification.

If you look at a six meter size-constancy target in a Disparator, for example, at far point, and measure its phenomenal size match and then move the near point position and make the new judgment, the figure in the near position will be seen <u>smaller</u>. Every principle of geometric optics demands that the converse be true. Why then the "paradoxical" change in size? The answer is to be found in the fact that the ground or surround subtends a much larger angle relative to the figure at near. Every good camera man knows how to use this fact. To dwarf a large actress he needs only to increase the relative size of the surrounds. Ground, the hardly noticed portion of the visual field, thus plays a decisive and important part in the process of figure formation.

Reverse the process and one may at once

differentiate the critical plane in space where the visual habitus of the preceiver breaks down. Such an observation should help, in a definite way, the doctor's decision regarding the often critical matter of the tolerable or functional limit of lens power to be prescribed and worn.

Figure may also resolve into a pattern of sub groups. The mechanism of this has been discussed in a previous paper (The Factor of Direction). The incubus to such refinement of figure structuring is always regarded as "from above", i.e., the forces which shape the sub wholes within the larger unity derive from the domination of the larger unity. This principle we have also considered previously and have shown that in biology the organism as a whole imposes, through dominance and isolation, gradients of chemical, electrical and mechanical forces which shape the 'parts'. Parts are not units to be summed or aggregated to produce wholes, but wholes set the plan or developmental and functional scheme into which parts must fit or die.

There is still another very powerful agent in the ultimate establishment of a figure-ground structure. This is not mentioned by Wertheimer. It is emphazised strongly and logically from the fact that even though the physical pattern which reflects light to the sense organ and is thence transformed into a pattern of relatively slow moving volleys of ions in the conductors and eventually sets up a pattern or electrotonic structure in the brain, yet may be radically transformed by the effector pattern of the terminal action, the backstroke from which becomes the residual ground which gives meaning to the entire process. This is the view of motor theory. To me it forms an essential supplement to configurational principles.

Let us be mindful first of the fact emphasized by the work of Beaunis, Richer, Stetson and others that there is no essential difference in the properties, attributes and operational characteristics of manipulatory acts of skill and the visual perception of forms. Both begin as undifferentiated masses. Both achieve form and specification as a result of a transforming process or series of processes. If early in the series <u>more than one</u> figure emerges there is tension in the field. The field is multipolar and disjoined. Schumann and others have shown that it is, in fact, only necessary to orient the sensori-motor mechanism <u>as if</u> a second point of light were about to appear in an eccentric position to a first point in order to produce in experience an essential but artificial diplopia. Since this can be done monocularly, the doubling must be regarded as a central function. It is only, therefore, when the perfect harmony exists between the executant motor processes and the perceptual ones that the latter attain the best state.

The motor block can operate retroactively. The tachistoscopic exposure of an 8 digit number may be clear and perfect. If in oral reproduction the perceiver 'stumbles', or pauses, he will find it difficult or impossible to complete the reproduction. Knight showed that perfect impression and reproduction are defined by the motor process instigated <u>even before</u> the appearance of the stimulus and carrying on through the successful and aesthetically gratifying consummation. Figure formation is an <u>active</u> process. In the terminal stages of maximal perfection from training any act of visual form discrimination takes on more and more of the motor and becomes, paradoxical as it may seem, less and less visual. The best see-ers are, surprisingly enough, far poorer in visual imagery than their less competent fellows.

It is often true that functions seen in pathological cases throw light on the normal operation so that we may come to a clearer understanding than we may otherwise attain. One of these is a case of figural blindness in a man, 24 years of age, reported by Gelb and Goldstein. The man was wounded by mine fragments, was unconscious four days, treated for head injuries and shock. After recovery he could speak and read; fatigued easily, showed tension and excitement when reading; behavior otherwise fairly normal.

He showed marked difficulty in preceiving simple line drawings and could only read <u>if he traced each letter of each word with his finger</u>. Acuity tests were normal. Words shown tachistoscopically were not seen, either at 0.01 seconds or at 0.5 seconds. Long words often took 10 second exposures. The authors report that this man could read only if he made a series of

head and hand movements which traced what he saw. The letters were traced one over another in the same position, rather than across the line or page. Thus the movement was the primary thing. When prevented from moving head or body, he could read nothing. His movements led to meaning only if made in the same pattern as in normal writing. When cross hatching marks were placed across a word he followed these lines and lost all sense of the meaning of the word. Simple forms had to be traced, such as triangles and circles, before he could name them. Complex drawings were difficult for him and all drawings representing perspective or the third dimension were without meaning. The authors do not mention the attempt to use bimanual explorations. The patient was completely unaware that his visual perceptions were different from those of any normal person.

After-images of forms could not be seen and named as forms. Tried with both real and apparent movements he could report no visual perception of motion. The patient never reported having any visual images and studies of copying, drawing, etc., tended to confirm this. He could draw well, but could not copy, particularly if a form was composed of lines intersecting the figure objects, thus causing the 'derailing' and loss of meaning. He could not, in fact, draw a single line after being instructed to do so. If permitted to 'trace' with head movements a tea cup or other common object he could draw or reproduce a type-form but not the particular pattern shown him.

Cases of this type indicate the consequences of disjunction, and also the essential role played by movements in the structural organization and unification of the visual field.

It is of interest in passing to note that the word myopia came into usage originally to denote the fact that the near-sighted strain and compress the lids. The field is disorganized through tension, and many exhibit a slowing of visual reactions that is quite characteristic. The time factor no doubt thus indicates something slower than the rate of nerve conduction. This time factor could be the slower motor backstroke, essential as a necessary portion of the ground upon which stable figures must emerge. Certainly a complete and thorough visual analysis should include at least a sampling of such essential functions.

Psychological Optics
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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part VI)

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Thus far we have described some of the laws and attributes of the process of forming a figure-ground structure. Such structures must be regarded as existing in four dimensions, one of which is time. Since the process of figure formation runs a course in time, and since the forces which shape figure exert influence only upon figure and are limited spatially to the boundaries of figure, the same process which creates figure organization will, if continued, ultimately reach an equilibrium. As it does, so some other portion of the field attains figure status. No cell can be active for prolonged periods without rest or change. No stable organization can be conceived in the energy of the signaling system of the body. Thus we may see how the so-called illusions of reversible perspective change without any necessary or operative change in any accessory adjustory mechanism.

Portions of the visual field within the solid angle in which forms or shapes can be seen clearly, exist as ground in the form of masses of light and shade. They are practically unseen and unnoticed and consequently lack sharp contours, differentiating detail. They belong to generic classes or orders. Their appurtenance to the total view is not derived from or dependent upon their developmental properties.

If we make them brighter, bigger, or fulfill any of the stipulations set forth in the preceding five papers of this series, they tend to become figural. If this process is reversed the return of figure to ground, even though no change in position, form, brightness, size, etc., need take place for such change, is marked by an immediate and radical change in impression value. All operational properties are likewise changed. One species of blurring need be nothing more than the perfectly natural change outlined above.

For a given perceiver it is conceivable that certain classes of objects in the world emerge as figure only on infrequent occasions and then only for short durations. For many people any clear grasp of such a concept as the size of the universe, God, the atom, etc., may be rare. Birds, even, or English words may be many things to many people because it must be realized that habit, training and attitude are weighty factors in the final level of strength or weakness and the final extensity of field organization.

Blurring may be a return to primitive state of figure organization or a recession to ground masses that are mainly unformed masses, more homogeneous with the total surrounds that any noted or figure object. There may be, of course, and no doubt are, other factors and types of blur. But we may see the process that resembles the listless stare into space of fatigue or boredom also as a species of the thing which may be seen in varying degrees in myopia; ground envelops the total field; things recede and blur; space closes in.

Two further facts must be considered. I may hear even soft spoken speech set in the intense and complex noise pattern of the shop or factory or the busy street, or I may hear the weak sound of an insect in the heavy silence of the deep forest. Silence that is heavy or oppressive may play tricks with perceptual structures. I well remember my own contemplations once when alone in a huge silent amphitheater in the high Rockies and the sudden shift occasioned by a small but salient and terrifying landslide. The absence of something may thus serve a positive role in figure formation. Ground, from this point of view may be what uncritically some may describe as 'nothing at all'. But such grounds are real things. They are strongly determinative of the figure experiences set in or upon them. They must not be disregarded.

Secondly, we must consider the fact that a visual figure may emerge from a veritable

tapestry of ground constituents which derive from every other sense modality. Here our knowledge, gained from careful experiment is fragmentary and sketchy. We do know, however, that the moment I look to identify a friend in a streaming crowd or to identify a speck on the horizon as a friendly destroyer the sensory, afferent volleys from hearing, taste, smell, the muscles, tendons, joints, organics, all comprise a non-localizable, non-verbalizable totality which is the ground for the visual figure experience. Within the visual field itself are the impulses from the extrinsics, from the ciliary, etc., and no one can deny the potency of their influence. Note what happens, for example, to position, size, form, etc., when we inspect any common object through a semi-pseudoscope. Any upset of the habitual pattern relation of address, posture, orientation can and does produce important effects upon the smoothness and skill of the executant act. The potential gradient of figure and ground must approximate an optimum. Ground can be too weak or too strong, too stable or too flexible. Ground, likewise, can be anomalous with respect to figure. When a sudden shift to a new figure finds it set in a prior but now inappropriate ground there can only be trouble and distortion.

The pitch or set of the ground may become habitual. The distance factor for a figure seen on the plains of Montana or Wyoming or on the undulant landscape of Massachusetts will differ markedly for the Easterner and for the Westerner.

In visual training, therefore, it must follow that cases should be met in which no ample and adequate figure reconstruction can be attained until there has been first the proper care taken to reorganize ground. In visual diagnosis the findings are bound to be in error by some usually undetermined amount likewise unless due regard and proper handling of the ground is taken. Keystone stereograms EC 10 and EC 110 may be cited as cases in point. The ability to fuse the targets in third degree fusion differs markedly on the same observer. The decentrations of the figure targets are the same. The ground relations differ.

The right kind of 'skills' analysis tells you what kind and how much the anisotropies of space, motion, time, relative position, size, sharpness, etc., are derivatives of sets of purely functional inter-relations. Moreover, it should point the way to every step which must be taken both in lens application and training if the patient is to receive what he has a right to expect for his fee. Whoever says, "I am not interested in skills" therefore says simply he or she is not interested in the most advanced and scientific effort to use every resource at his command. Such talk is just so much talk and can be disregarded.

If proof is needed to substantiate the role played by figure formation and its relation to grounds - fore, mid and back - the evidence is not wanting.

(1) If the shadow of a hand and forearm are cast upon a screen to produce the phi - effect (movement seen in the absence of anything moving) and if now the thumb of the hand is flexed a few times, stopped, then flexed again, the <u>rate</u> of the seen movement is observed to diminish by about one-half. If now all the fingers and wrist are thrown into active movement, the apparent elongation of the arm stops. When movement is strengthened in one part of a field to heighten the figural organization in that part, motion in the ground is diminished or arrested.
(2) In stereo-tachistoscopic exposures of a truncated pyramid, if the figures are seen upon a white undifferentiated ground, the minimal exposure for third dimensional form is about that of the visual reaction time, i.e., about 220 milliseconds. If now a microstructure is added as ground, depth may be seen in exposures of 1 millisecond, even by untrained observers.
(3) In ambiguous figures, where reservals occur colors seen as figure posses different properties than the same colors seen as ground.
(4) In split Stereograms after fusion is achieved ground may move or change space orientation with no change taking place in figure.
(5) Pictures possessing strong unity, i.e., strong figural organization, resist the intrusion or addition of any extraneous or incompatible figure. I could not affix standard three meter König bars in twelve millimeter patches to the surface of a Rembrandt painting. They always stood out in space well in advance of the picture plane. They could be merged without effort within an inferior painting.

Case after case could be cited. Targets, apertures, relative brightnesses within fields and other similar things are real factors of influence wherever eye, brain and muscles lead to the report of what you see.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part VII)

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Considering the bidimensional visual field, figure begins as one or more masses. It emerges from its ground by a progressive, developmental process in the course of which segregation is enhanced by contour or boundary formation. Brightness, contrast, size, positional and other differentia all play a strong part in the process of the change of it to thing. When does figure achieve its best state? Its final or eventual perfection?

Perfect figure is attained when all the internal forces of organization give to figure the maximum of unity. This state is measured by such operational means as its inertia-factor or resistence to distortion or change, either by alteration of the surrounds or by the addition or subtraction of components within the figure itself. Unity means cohesion. The "parts" belong and tend to remain as one, losing their separate identities in the amalgam of the whole. So saliency, 'hardness,' domination are properties of strong figure organization.

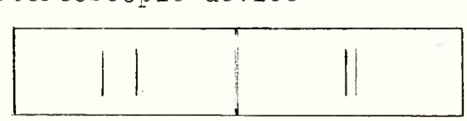
In a previous paper reference was made to a similar function in living biological systems: When one 'part' or region becomes dominant its reciprocal influence is to isolate other field structures and thus to form gradient patterns. These are strongly determinative of both functional and structural activities within the entire system.

The close parallel to figure-behavior within a perceptual field is a striking and important fact.

The strong emergence of a figure may distort space relations within a field. If first a strong pressure on the skin is followed by a weaker one at some little distance the separation will be phenomenally less than is the case where the intensity and time relations of the two stimuli are reversed. Visually it is the same. The whole system of space, time and motion relations within the visual field may be shown eventually to be dependent upon the degree and extent of such field organization.

It will be recalled in Pavlovian studies of conditioned delayed and trace responses that the experimental animals, if the period of delay was made too long, went to sleep. This was 'explained' neurologically as an irradiation of a local sleep, first limited to a small, restricted brain area, thence spreading to finally take over and dominate the whole cortex. A similar kind of theory has been proposed to account for hypnosis. Going into the trance is at first a figure-fixation within a ground set in the direction of lower and lower muscle tonus. The final somnambulistic stage is one resembling the extension of figure to fill the entire field. Figure has so completely dominated that it has suppressed ground.

In the simpler instances of the two-dimensional visual field the growth of figural strength may be observed. A variation of one of Titchener's stereo experiments will illustrate. If we look at this figure in any stereoscopic device

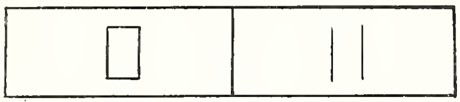


when superposition of lines 1 and 3 is attained, 4 and 2 are said to fuse, i.e. a new line is seen, shorter and in a plane nearer the observer. The third visual dimension thus must be a phenomenon whose behavioral or operational properties are to be sought in the descriptive facts of field structuring or field-dynamics.

I have shown that if lines 4 and 2 are made qualitatively different enough (Even so simple a change as position is enough!) 'fus-

ion' actually never takes place but the emergence of the third dimension is always marked by the same process seen in the simplest phi or phenomenal movement case, namely, the alternation of the two lines as figures.

If now we make one small change: Draw the left pair like this:



Use as thin lines as you please so that they are just visible. Now no such consequences follow as before. Line 2 is still there as it was originally, but its rôle is such as a component of a rectangle or stronger unity that it is not "free" to 'work' with 4. No depth is seen.

Blacken in the rectangle and the figure unity or resistence to distortion is still greater. 'Fusion' is not only impossible, but luster may easily be seen. That is the surface black of line 4 may be transformed into the filmy, transparent black of luster. Here in such instances we see how figure may develop form, unity, inertia, resistence to distortion, and in so doing exert strong influence to reorganize the field beyond its own limits. I strongly suspect that this is the phenomenal origin of at least some of the anisotropies of space, form, position and movement. Figures can be weak or strong; transitory or persistent. They are the experiential paradigms of the aggregation and segregation of forces within the sensory-cerebro-motor mechanism.

Thus far we have dealt mainly with relatively simple two-dimensional fields. In the three dimensional world the organization is more striking. I look out my fourth-floor window upon the sharply-etched gray-brown trunk of a large tree, strongly emergent from the green grass which, from my perspectival point of vantage, slopes up and out behind the tree. But the green grass sheet is broken by a network of brick walks over which miniature-appearing students are hurrying to and from classes. Buildings and streets set boundaries, except for a central gap through which space reaches out to a distant tower behind which the sky bends down to meet the earth. How much of this is foreground - so greatly important in forming the total 'picture' that I see? How much is background? Midground? What would the vector quantities look like on a three or four coordinate system?

Speculation runs on. Before me is a new roll of decent-size color film. The day is clear. I should like to record this scene in color stereo. But my camera has an 80 mm + 1:2.8 Tessar lens. At what PD shall I expose the left and right views so as to give least distortion? Can I recreate the scene at all to any reasonable degree of tri-dimensional fidelity with this equipment, - or shall I bring out the 17 inch 8 X 10?

My problem, or that of anyone, is only in part the problems of optics, of exposure, of stops, of focal lengths of lenses, or of appropriate stereo demand-meeting. I must make something which on a large screen approaches the perfection of taking the observer empathically into the figure. Geometric optics can help but it cannot tell but part of the answers to the highly important questions relating to how something can be made, which when viewed, will give me the same figure-ground pattern -- (of such complication!) that a moment ago showed me a new facet on what probably was the ten thousandth time I have looked at this 'same' scene in the past twenty-one years. And, more difficult still is to make something which will be easy for one, viewing the scene for the first time, to reintegrate the pattern.

We would not dare to forget that one reason my photographic task is so difficult is that the tri-color pile of the color film emulsion and the corrected objective of my camera record with great fidelity the wave-lengths, intensities, and angular spaces. But my eyes and brain and muscles do not do this. They correct, discount and amplify. No one yet has built a camera lens incorporating a correction for size and form constancy. No one has made an emulsion to correct for brightness and color constancy. But these are the external verities we see. These are also the infernal factors which cause us to say "not a good likeness of the scene," or, "the distant tower is far too close;" "the color is wrong," etc.

Space, we must realize, is an abstract way of saying that we have from infancy built

up around a visual matrix, an intricately structured set of behavior patterns. We should be wrong, from our point of view, to hold that it is a formal lattice in whose framework are set the contextual objects we see. The objects themselves only are objects after they become cortical objects and space folds-in precisely as the dynamic interplay of forming forces permits.

It is the contention of the writer that however valuable stereometric devices are that measure only decentration or relative or coordinate displacement, they tell only a fragment of what one wants and needs to know about the visual perception of figure-ground structures and their anomalies. It is further contended that if full and complete description of what is seen is secured from a few carefully chosen and properly made stereograms a close approximation to the true appraisal of the observers seeing proficiency can be obtained. It is further held that direct measurement and description of total functions is a sounder procedure than is the algebraic summiation of what are assumed to be the measured essential sub-parts of the whole function.

Earlier it was stated that a further differentiation of figure and ground lies in the characteristic differences in their contrasting behavior in retention and recall. The work of Köhler, in his series of experiments describing figural after-effects, both in two and three dimensional space, is so outstandingly important that we shall attempt to summarize these contributions in the next few papers. This work, in the opinion of the writer, will be recorded as one of the truly great contributions to visual science.

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FIGURE AND GROUND
(Part VIII)

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The concept of figure formation, in one sense, is as old as von Ehrenfels' formulation, about 1890, of the idea of form-quality. One of the significant properties, said he, of any perceived object was its form. This form-quality could be more - and in some instances less - than the sum of the object parts.

Now one of the basic facts about figural forms is that form is not dependent upon or determined by the constituent 'parts.' From this it follows that forms are transposable. Transposition means that form can be abstracted and generalized. A specific form in one setting can be taken over into a new setting or in the same setting different parts can comprise a similar or even an identical form. This may be clearly seen in musical composition. A melody in the key of C can also be played in G, or F#. The listener hears the melody as the same although the keynote or pitch has changed and the frequency relations of the separate constituent tones has likewise become something physically quite different. Tears came to the eyes of a 17 year old girl who for the first time in her life could read the hymn numbers without lenses from the rear of the chapel. She has been pronounced a high myope for whom it was said nothing could be done. Yet in two weeks of training, principally with Koenig bars and green and black rings, important gains in far point vision were noted. The important thing is that when form is mastered as a manipulation of visual space, it is unimportant what kind of shapes are used in training. This is because of the transposability factor mentioned above.

The importance of this general law of formal transposition is great. That it is not well understood may be illustrated by a letter recently received in which it was stated that a person giving a course of lectures asserted that in training myopes to see forms at distance, letters or numbers should never under any circumstances be used! It would be interesting to examine the supporting evidence (if any exists) for such an assertion. Such statements can be disregarded since for fifty years every student of visual form perception has seen abundant and convincing evidence of the principle of figural transposition.

Not only are figures transposable extrinsically, but they also possess an important intrinsic property of transposability. For lack of better understanding of the process this is sometimes called meaning.

Let us illustrate. My study window faces the west. Below is a flower garden. Here is a row of pansies - of many colors and forms. If we stand a dozen or fifteen feet and face the row of flowers at a right angle, on the right is a cluster whose appearance startles us. They are human faces. One in particular looks like Mickey Mouse, another a caricature of Stalin. Now let us slowly walk forward. We soon reach a point where, within a range of a few inches, the pansy head is no longer seen as a face. The masses of color and brightness and line which formed the faces are replaced by separate patches of color, separate radial lines, separate petals, etc. Unity has disappeared to be replaced by a different kind of thing. Now come with me inside. I project on the screen a 2x2 black and white slide of the same pansy. The image is sharp and clear. I begin closing the iris diaphragm and the screen is gradually darkened. Soon a point is reached where, suddenly and without warning, a face replaces the flower.

We make another experiment. This time the lens tube is shortened as far as it will go and the projector turned on. You see only

a central patch a little brighter than the rest of the screen. I take the tube out a little in the direction of clear focus. A little more. A little more. Again you suddenly get a face - it came out of 'nothing', i.e. mass, blur. We continue on. Soon we reach another point. The face is gone. It is now a pansy.

These qualitative perceptual differences indicate clearly, it seems to me, that there is an important intrinsic transposability within every form. For men and women of perceptual range and nimbleness there may be numerous transitional forms. For Wordsworth's Peter Bell and his kind

"A yellow primrose, by the river's brim,
A yellow primrose was to him,
and nothing more."

The faces emerge from the pansy because the masses of simple, primitive, early, undifferentiated stages of perception fit most readily the stereotype frame of reference. The face is lost just as soon as detail, contours, colors segregate the 'parts' and this now best fits the classification 'pansy.'

The act of perceiving form is therefore a single process in part dependent upon the organization of the physical object. That is to say the size, position in the total field, colors, brightness, contours and contrasts, etc., start to give final form. But not until the sensory-cerebro - motor portion of the process within the perceiver is completed. The terminus of the process may be naming the object, further segregating it and strengthening it as figure, or conversely classifying it as or aggregating it with the ground as some other portion of the field becomes figure. This relation between the object out there and the cortical object, i.e., the object as phenomenally experienced, was claimed by Wertheimer to be isomorphic, and molar. Issue can be taken with isomorphism on the ground that it implies a strict dualism of object and perceiver which many deny. And there is the disregard of the fact that the whole process is antecedent and instigatory to the consummation - the fact that the perceiver <u>does something</u> about what is out there. He may name it, group it, look more closely, or turn away. But it is always this thing he does and its consequences subsequently that are of the greatest importance. The greater the skill in figure formation the more ready and effective a man is to deal with his world. We continually emphasize the point that often the most rapid and effective way to reorganize the processes of perceiving is to begin by setting in order the executant motor process which the figural impressions are ultimately to instigate and energize. Conversely, as you can easily demonstrate, the surest way to hamper, interfere or even annihilate the process is to follow the impression at once with a blocking or hesitation or the introduction of an incompatible movement. Knight showed in his dissertation that the foreperiod, the things the perceiver does <u>before</u> the impression, and the things he does <u>after</u> the cessation of the impression, are just as strongly determinative as any phase or aspect of the impression itself. Facts of this type are highly important in all visual training work. You must work <u>with</u> them to get good and lasting results.

From the above it will be seen that the writer was hard-put for a simple answer recently when a letter was received from a young man who practically demanded that I send him a list of exact specifications for the correct making of targets to be used in diagnosis and training so that the correct and most effective relations of figure and ground structure would be had in each. Obviously, targets can be made and some have been made, which present certain planned relations. But even these will only give the kind of results which follow upon the proper handling by the operator. No target ever can or will be made for perceptual training which can be routinely used in a nickel-in-the-slot fashion. The essence of the whole matter is that materials and instruments of whatever sort are only tools, instrumentalities which give one results in the hands of an expert and a dismal other sort in the hands of the novice who does not possess or use the requisite knowledge and skill.

The proper control of the process of figure formation and figure-articulation is more a matter of control of what the perceiver does than it is of the type of stimulus figure employed. There are of course well known factors which must be taken into account in the making or selection of proper training materials. But often it is implied that an impression-figure contains within itself the sole determining factors that produce some specific effect. This is probably rarely if ever true. For example peripheral sum-

mation has proven to be a most effective and useful technique in the reduction or elimination of myopia. There are several ways the desired effect can be produced. At present no one can safely say that procedure and material No. 1 is 30% superior to procedure and material No. 2 for any specific subject.

The discussions of these papers in volumes 5 and 6 are written to show new horizons; new problems and ways of attacking problems in seeing. It must be realized clearly that many of the questions which arise as we read or write such papers can only be answered by much careful work - research of the best and most carefully planned type. Valuable as clinical experience and insight is, it alone can never give the answers. It lacks the essential controls, differentiations. It does well what the laboratory alone can not do. Both working together are capable of producing results of great practical and theoretical value. I am convinced that as of 1946 we are doing, with certain isolated exceptions, next to nothing about it.

This paper represents the three-quarter post in Vol 6 of this series. Some of the laws and facts of the figure-ground relation have been described and commented upon. These papers were written because of the conviction that this new step in the direction of theory holds the potentialities of rich rewards for the future. Now is the time to master the fundamentals - to be ready. It is a simple statement of fact that we have witnessed effects produced in the laboratory in a short time by experiments designed upon these principles which one or two years ago we would have regarded as impossible - changes in acuity, in phorias, in third degree fusion limits, and in other highly important visual functions. We feel that we have made only a mere beginning; that we have before us years of careful work to do to be ready to speak with finality; that those who conclude prematurely and finally as does Dr. A. C. Woods that "visual training is useless and ineffective" in training the myope to see at distance, have no just right to make such untested statements.

Consider, for example, the mathematicians null hypothesis. An event Z̲ is presumed to be causally related to C̲ which operates in the presence of A, B and D and E. To prove that C̲ produces Z̲ independent of the agency of A̲, B̲, D̲ and E̲, C̲ must be reduced to zero in order that we may be assured that C̲ and not A̲, B̲, D̲, or E̲ is the significant contributor to the effect Z.

D. Katz has proposed a similar methodological principle called reductionism. If you wish to study contrast effects, uninfluenced by area, contours and other 'error' sources then the pure contrast effect must be reduced or freed from all other possible influences.

Thus to say as I recently heard a leading ophthalmologist say that near sighted persons, after training which improves their vision even to the point where minus lenses are no longer needed, are still myopes, is a statement which clearly calls for both his definition of category of myopia and proof that the final classification meets such an accepted definition. Resolution is not a satisfactory criterion since a hundred myopes with the same Snellen or Köenig acuity will vary widely in the lens power needed to give them acceptable or approximately normal acuity. Likewise static retinoscope is not satisfactory because another hundred who 'scope' the same will vary widely in ability to see at distance. The subjective finding is similarly unsatisfactory. Few could or would accept and wear the pure subjective as taken customarily. What mathematical equation can therefore be written to combine these three or any number of such findings into a single measure which falls within the precise limits which define myopia, or any visual anomaly?

Here is a person who sees singly, binocularly and clearly at far and at near. No lens that can be placed on him will add to his comfort or visual effectiveness. How can such a person be anything but visually normal? Figure must be regarded as an energy distribution in space which approaches an equilibrium. It will tend to approximate its best state. When the ground is weakened or strengthened as reduced in area changes in figure are conventionally noted. Figure and ground are not two things - two geographical loci. They are the descriptive names for portions of the total field and are operationally defined. The description of them in perception is but a part of the whole story. Their behavior in retention and recall will next be examined.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part IX)

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It is doubtful if one can readily think of any concept which has so many bearings on visual processes as the mechanics of the formation of a figure on a ground.

In the series of papers on this topic we have tried to review a part of the development of this type of thinking from theory and experiment. We shall need to discuss a further phase.

Out there in the world beyond the limits of our bodies are objects which reflect light and excite our distance receptors. The blue-green pottery pitcher across the room from me I class as a pitcher, although not set in the baseball frame and although it is filled with garden flowers it would demand some effort to name it a vase. At any rate it has a distinctive shape or form, a bulging base, a long cylindrical neck, a spout and a graceful handle.

If I wish to record faithfully this shape by a sketch or drawing, I must look at it carefully enough so that the above named "parts" are correctly disposed in space. Otherwise my sketch will not closely duplicate the original form. Only as I can project the light pattern which reflects to my eyes from this object in their true relations do I see the pitcher. If I watch a five year old boy in his effort to draw the same pitcher I see him quickly in difficulties which are prima facie evidence of the stage of development of his ability to "see" the object. One thing he has only partly learned thus far: He cannot shift from the impression or looking phase of the process to the executant motor act of making strokes with crayon or pencil which in tactual, kinaesthetic or motor terms is designated as the same as was seen in the original.

Now let us keep in mind this fact. When university students, without visual controls, learn to trace a maze pattern in a learning experiment, they come to know the space relations of the maze paths in tactual-kinaesthetic-motor terms. When they see the maze for the first time it is always true that they are surprised. The visual appearance of the maze is nothing much like the total impression formed from tracing it. One good and sufficient reason, of course, is the fact that only a small portion of the maze pattern can be felt or touched at any one time, while visually the pattern is seen, if at all, as a whole. Another reason is that we strongly suspect that in the evolution of our sense organs, the distance receptor which fails to report impressions which localize things in space and give accurate form-representations leaves the organism in poor state to prepare for flight, defense or manipulative control. The entire process of "seeing" thus is helpful in so far as the final dispositional movements we make to any object-stimulation are aligned with the basic set or objective which runs through the whole course of the action stream. The prism experiments (Stratton, et al.) early testified to that fact.

The history of the experiments on space localization on the skin, in hearing as well as in vision gives us further clues that where we put the figure object is a function of field structure.

We must think of the whole sensory-cerebro-motor system as a complex force field. Further we must remember that movement is the very essence of all mental life: that the "common denominator of meaning" is kinaesthesis (Titchener) and that these important after-effects of serial actions are diffused, poorly localized and still more difficult to describe. They are, for the most part, the stuff from which, as the all important ground, figures emerge.

Let us remember too, that heretofore we

have emphasized that the energy density pattern received by the sense organ is not and cannot be transmitted in the precise form it is first received at the sensory surface. The afferent pattern of volleys in the nerve are relayed again and again before they reach the brain cortex. They are also admixed with those from the skin, tendons, joint surfaces, the ear, the semicirculars, etc. The brain pattern of active energy distribution as I regard the blue-green pitcher of shasta daisies, calendulae and coreopsis, emphasizing only the pitcher's shape, not its color, or texture, or weight or volume or temperature, is in all probability one in which there is a cortical region of high potential enclosed in a field of energy flow, more loosely organized, so that the focus or center, (i.e. the cortical object) is bound by forces all oriented toward the center of this central high region.

There is nothing strange about the concept that in a living protoplasmic system such a region becomes dominant and relatively isolated by the subordination of adjacent regions. We have discussed this in previous papers of the series. Köhler has shown that if the brain is regarded as a solid conductor, the spread of potential within such a system will produce such a design of organization if the transferred energy pattern from the sense organ is shaped or patterned and if the region within the solid conducting mechanism has a uniform conductivity.

It is well known, for example, that if we think of a space-solid with coordinates x, y and z intersecting at its center and if there is a region which is highly active on the + X vector (say, from a region in chronic high tonus) and a small and not too strong locus on -X not far distant from O is activated, the apparent position of the second locus will be shifted to the right. Its rate and amount of positional deformation will be defined by the areas, time, intensity and other operational attributes which define the relations of the two energy foci. This is the paradigm of a phoria.

In such a system with two separate 'figures' in a single enclosing ground tensions will be formed so that space is less free; movements are restricted; sizes will be altered; apparent distance changes (Z - axis vectors) may follow. The only possible criticism I can see that can be legitimately levelled at the concept of phoria as a space anisotropy is that our present concept does not go far enough. We neglect the Z-axis and treat X and Y as two distinctive varieties of things. Actually I should like to submit the notion that our Size-Constancy measurements and our phoria measurements as planar, lateral and vertical space - - displacements are phases of one and the same tri-dimensional phenomenal space. Further that whenever the relations between figural loci are altered by any means there will be a corresponding alteration of the external reference or projection of their relative positions. Finally, it also follows that because of my height, weight, and habitual musular reaction pattern, in fact my general make-up as a moving, active animal, the space world which I set up as my empathic lattice will stabilize and stereotype certain of these intra-field relations. This is sufficient to insure that independent of what I see, where I see it in relation to other portions of the field will be a direct function of the inherent organization of my field.

Blurring, amblyopia, diplopia and such like become straightforward functionally describable processes when regarded from this point of view. We need no deus ex machina to "explain" them. We can set about to make experiments to describe them and therefrom learn the laws of their control.

One man almost ruined the world by a colossal enterprise of 'divide and conquer.' If division of what is, in its best state, one, into many, results in tension, malpositioning, form destruction, fog, blur and trend toward chaos, where can we find clearer examples than in the field of vision?

Seeing is an active process. It is best when its structural form is unitary, coherent, resistent to distortion. It attains these desirable properties not because the Creator was particularly partial to the eye in the family of the sense organs, but because the eye evolved as better suited to operate with the effector organs in the fabrication of an effective space world than any other family member.

Let us not forget that psychologically there is not one space, but many. How different are the spaces of the active and the passive touch; of the moving and the

resting single and double eyes! If the visual components were the primary things there would be but a single space. The fact that the tactual third dimension is different in phenomenal size from the visual is well known. Even within a single modality, touch, it makes a great deal of difference whether the space judged as equal to another extent is empty or filled. Visually two squares appear different if one is black or stippled and the other white within the limiting boundaries.

Does not the foregoing point to the view that a considerable part of the flexibility which permits man to adapt quickly to new surrounds, lies in the fact that he can change his space world?

Finally, it should be true that when proper visual training procedures are used it is almost certain that the correction of space distortions will bring several functions into harmony, and one suspects that the number of such has been regarded as too large. It is likely that important changes in both theory and practice will be seen in the next few years. They will be based on field dynamics. There are evidences now with us.

Psychological Optics
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FIGURE AND GROUND
(Part X)

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We must not leave the consideration of figure formation without a brief look at one of the most important facts about this all important process. The question before us is: What precedes or lies back of the achievement of the final status of a figure on a ground?

The average person, if shown a watch or an alarm clock or an hour glass, at once identifies this object. He gives it a name or classifies it. If he is very young or limited in his stage of perceptual development he will likely call it "something to tell time by." His definition will be in terms of use or function. If he is more developed he will use properties or attributes. Finally if he has reached an advanced stage of perceptual development he may show the maximum of critical elaboration. He may resort to an even better form of language to suit his purpose, namely expression of a set of mathematical equations and from these he may literally take the concept of time-piece out of time and space and deal with it abstractly, i.e., reduced to its simplest intrinsic terms. If his bent is artistic and aesthetic he may turn to design and end with generalized forms and functions far remote from the simple, everyday or commonplace object which elicits from the infant the words 'tick-tock'. No matter what the stage or elaboration of the process or of the perceiver, one fact stands: When asked about it each in his own way will report that the perceiving of the object was immediate: He looks at it and there it is and he knows it at once. The process is one and simple.

In contrast to this view we who have given some study, thought and experimentation to the process hold that the above view is fallacious and deceptive, and that the process is even in the simplest cases mediate, involved and incapable of valid and competent introspective examination and report. It is this difference which shall be the object of our inquiry in this paper.

Now there are those who dissent from this view. It was my privilege to lunch recently with one of them, a very able professor of philosophy. He spoke to me at length of the shortcomings of psychologists, which happens to be my craft. He emphasized and insisted upon the intuitive knowledge (i.e. immediate perception) of common objects which, it seems, is an important matter for the philosopher. I left the very delightful hour unconvinced. This was because I was certain that his statements came from looking within for an examination of his own private mental processes and is so doing missed completely the limitation mentioned above.

Let us review some of the facts. Suppose I were walking through a forest with this gentleman. Suddenly a bright object is in front of us. He was the first to notice it, and the first to name it, an alarm clock. In the unusual place it was seen (in the tactless forest with no sign of human predecessors) let us assume that a tiny fraction of the light reflected from the object reached his eyes as a quick and different flash from some considerable distance back. Assume that this was unnoticed, dismissed with a "What was that bright flash?" kind of shrug and we walk on, talking meanwhile about something else. As we get closer he becomes aware that there is "something out there." He cannot see the face or numbers, -- the case, let us say, is an unusual and artistic shape. He now begins to try to see. He looks sharply seeking some clue to the unvoiced question, "What is it?" A step closer and he exclaims, "Ahead lies a box with a glass front, let us walk over and examine it," and a few steps farther, "Fancy what would an alarm clock be doing here?"

Such an imaginary case is by no means ex-

ceptional in everyday experience. It illustrates most of the stages through which every perceptual act passes. Not in all cases however, for it is well known that some stages may drop out completely. The whole process can become foreshortened in the same identical way that a white rat begins the prodromal stages of eating (increased peristalsis, glandular activity heightened, etc.) almost immediately upon entering the maze of blind alleys and true paths which lead him to food. Actually after many trials he may begin these things the moment the assistant handles him in removing his from his living cage to transport him to the experimental room which houses the maze. Moreover, he may even show the first beginnings by the mere lapse of time if the trials are evenly and regularly spaced and his life and eating has been sufficiently stereotyped about that act of maze running in order to eat.

No one can deny the facts of sensory and motor condensation. We must not fail to appreciate, similarly, the fact that a process that has been so telescoped that it runs its full course in a tenth of a second, is the same elaborate process divested of all save the very beginning and the end.

Let us return to the laboratory. There we shall perhaps find, as is usually the case, the real satisfying answer to our problem. Can we find substantiating proof for the proposition stated earlier: That the figural process which reaches its best state does so through the mediation and transformation of sets of field forces which run a course in time? That the whole cognitive process is set in an older framework which is motor and which not only antecedes it, but also gives it its essential meaning? Can we duplicate in the laboratory the same essential stages through which the normal process of figure formation passes and thus witness the processes of foreshortening and other types of transformations which take place with extension in time? Fortunately we may have recourse to several well known methods and to the work of several previous investigators as well as to results from our own experiments.

It must be constantly borne in mind, as we have pointed out elsewhere that the sensory is always productive of a trend toward instability and the upset of equilibrium within a system, and that the motor movements instigated by stimulation tend toward stability, restoration of equilibrium. It is altogether likely that we must look to the motor processes therefore, for such constancies as we may have in meanings, since it is well known that in the purely visual field figure structures are in constant flux. That which was part of the ground a moment ago is now figure and this in turn is replaced by something else a moment later. Figure processes prolonged in the same locus tend to obliterate themselves. This is called extinction. It means simply that the energy reserves within any sensory-cerebro-motor system are not inexhaustable. There must be some time for rest and repair following not too long in the wake of stimulation and reactance.

Likewise we must not be unaware of the findings of a number of investigators who have studied the problem of the retention of impression patterns, particularly by the method of serial reproduction. If our friend came suddenly upon the alarm clock in an unusual place for such articles to be seen, how will he describe or report it twenty minutes later, an hour, a day, a week, six weeks, three months? Meanwhile, of course, he has seen and done many things. We know from a score of such studies that what he recalls is not what he saw but what he has done with and to the figure process since that first impression. He may elaborate and supply details not present in the original. He may slough off details and stereotype his report, even to the point of complete reclassification; all done, let it be noted, in the best of faith.

The important consideration is that the perceptual transformation of the figure process always takes the vector set by the longer section interests, biases, trends, which are characteristic of the perceiver's action system. To what extent typological considerations are possible here is a moot question and need not entangle us. One thing is certain: The processes in retention are mere continuations and extensions of the same processes found in the original impressions, no more no less. If our adversaries grant us the above established facts, then they cannot deny the inescapable consequence, namely, that the primary figural process itself is from the first instant in a transitional and tentative state. Figures

have to be actively formed. The process begins even before the appearance of the first impression. In many cases, as everyone who has seriously worked at the making of psychophysical judgments will attest, the die is cast in the foreperiod and there would never be any question of the outcome if we had some good and sufficient means of showing to us clearly all the determinants of a judgment working just prior to presentation of the two comparative stimuli.

My teacher in experimental psychology, the late Professor Albert P. Weiss, designed an instrument which he named the Focal Variator. This is an optical device which permits one to show upon a small ground glass screen anything which can be drawn, printed or photographed. The image size and brightness can be kept constant while it is changed serially from blur to clear. The amount of blur can be measured in terms of the number of turns of a vernier on a 16 pitch screw, that is in sixteen hundredths of an inch of the focal distance between complete blur and maximal sharpness. I have made a number of experiments with this apparatus. Let me describe briefly one --- one which throws additional light upon our present problem.

Suppose I show you a photograph of the scene described previously in this paper, an alarm clock set in the midst of a surrounding forest. I show you first something which is so badly blurred that you are only able to report that you see a field with irregularly disposed patches of slightly different brightness. Note that there is no hint of object vision at this stage. We are therefore studying the basic, raw beginning of the process of figure formation. All is ground. Undifferentiated save for the noted brightness differences.

Now I move forward a little the lens system toward the clear end of the scale, not much, just enough to make a small difference in the visual appearance of the pattern. I record your remarks. I make another change, and record again, and so on until you are satisfied that it is unnecessary for me to carry the process on to needle sharpness optically, because you will undoubtedly have reached your perceptual limit long before this state is reached. If I show you pictures of objects, words from different languages, technical words from our own language, etc., what do we learn about the process from such experiments?

Mainly that there is an important factor which we may call cortical-motor supplementation which enables the perceiver to identify the image earlier and farther back in the blur and see it clearly. The greater is this factor the less the need for sharpness, brightness, etc., in order to consummate the perceptual process. When we trained observers with lists of pairs of meaningless syllables and two place numbers so that they could identify any one, given its paired mate, and then mixed these with an equal number of new and strange pairs, the measurements gave distributions which showed practically no overlap and the means were separated by a statistical difference amounting to virtual certainty. The same was true when we tested students who has studied a language, say Italian, for two quarters in the university and the same words were given to those who had studied the language four or more quarters. The purely sensory components become less and less important approaching a minimum.

The main difference between the two cases, when a perceptual pattern emerges from the blur to clear identification, and the rapid and apparently immediate naming or classification of a figure object is in the time required for the processes to move from the preparatory foreperiod to the final consumation.

This fact is attested by the following kinds of experiments. Suppose I use a tachistoscope which gives me a minimal exposure of 1 millisecond. Suppose I also blur the image by focusing so that the only report that can be given is that of a quick flash of light. I then turn the focusing pinion a little (a specified amount) in the direction toward clearness and repeat the exposure at the same exposure time, asking my observer merely to describe as fully as he can what he saw.

Here I am forcing him to see the view totally and as coherently as his referential frames will permit. In our laboratory Miss Douglas, a graduate student, has recently completed the analysis of more than 900 such reports from 15 observers each of whom repeated his sittings at least a dozen or fifteen times. Her results completely confrim those of Bartlett, Judd, Carmichael, Wulf, Helson and other students of this problem. They show that such analysis of the stages of the process of figure formation is al-

ways more or less stereotyped as to form, all going through the early stages of poor articulation, groping for meaning, filling, etc. Actually much can be told about the observer from the characteristic way in which he casts his descriptive and interpretative responses. Diagnostically the methods above described seem in many ways superior to the cumbersome and uncertain scoring Rohrschach procedure used by psychiatrists.

If we confine our interest to the purely visual aspects of the matter we may note for example that the 17 year old who is a poor reader, myopic, etc., is also weak in her ability to grasp visual forms in short exposures and, moreover becomes still poorer when required to give some objective evidence by sketching or fully describing common objects or scenes. Any kind of visual training or any other so called eye corrective work which neglects to repair or bring up to a reasonable parity the purely motor phases of the total process of perceiving, is bound to leave the young lady still weak in one essential grand division of her phenomenal world.

Experimental evidence from the methods of serial reproduction, from the focal variator, and from tachistoscopic exposures all show the same properties of the course of figure formation upon the basic, primitive ground structure.

As we come to a fuller and clearer understanding of the limitations of the purely optical and ocular aspects of seeing, we come to a position where we are better able to add real cubits to this most important functional stature.

Psychological Optics

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OPTOMETRIC EXTENSION PROGRAM

FIGURE AND GROUND
(Part XI)

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We come now to the last paper in this series. The end of the series is not the end of the problem. The relation of the figure-structure to its supporting and sustaining ground is one of such great importance that much more will be heard of it in the years ahead.

If you will go back and read all the papers of Volumes 5 and 6 before you read farther into this one, you will see the significance of an early statement that Rubin's discovery of the concept of figure and ground was of the greatest theoretical and practical importance. Let us look for a moment at a concrete case.

Here in the laboratory in recent months we have made a number of experimental studies of the dynamic inter-relations of ground and figure. We think of the figure process as a simple instance of object vision. We know that to see and identify an object the process must involve nervous mechanisms in advance of corpus striatum and must energize conduction gradients within the cortex, the impulses from which pass to effectors which in turn return volleys of afferent impulses to the same cortical regions.

If we look continuously or for only a brief exposure at an object, the backstroke plus the postures of address and orientation are there as essential portions of the ground, together with those perimacular and peripheral segments of the visual fields found in the immediacy of the figure region. A topographic map of the energy distribution both on the retinas and in the cerebrum would show a potential drop entending radially from the central figure region. If this relation is reversed then that which was ground a moment previously becomes the salient figure and the erstwhile figure region recedes and becomes part of the ground. Figure and ground thus are defined in terms of the amount, rate and direction of energy flow. This in turn is determined by a number of things, such as contours, boundaries, relative sizes, brightnesses, appurtenance, etc. We should expect to be able to test this kind of formulation with comparative ease. If we set up conditions in which strong processes (i.e., processes which have superior properties such as movement, tridimensionality, brightness, symmetry, homogeneity within the field structure, etc.) are set up in the field surrounding the figure which is simpler and less durable, we should be able to weaken or even to abolish figure. Two of us here at the laboratory (C.H.P. and H.M.S.) have recently completed a series of such observations. The findings are in complete harmony with the above theory.

In one case, a girl in training was found as a result of certain other training procedures to have greatly reduced her tachistoscopic skill and regressed in her reading. Work on the periphery was immediately stopped and she was given near point tachistoscopic training on digits in a completely dark prefixation field. After three or four training sessions she did better than ever before tachistoscopically and her reading returned to a new level. We are convinced that any visual training procedure will produce a satisfactory result only if such procedure is in accord with the gradient law; that you must always work in the positive direction of the gradient. If, for example, you excite periphery discontinuously you may thus reinforce and strengthen figure. If you weaken ground you reciprocally strengthen figure because you have heightened the slope of the potential gradient. If you create a secondary figure in the peri-figural field the primary figure will alter as to position, size, sharpness, resistance to distortion, etc., in proportion as the relative field strengths.

In cases of anomalous space projection, that is where an object or target is seen to left or right or above or below or nearer or farther out than its true position, we should expect to find that if a force field that is symmetrical is established well out in the surrounding ground, the projections should move to a position approximating the ortho or better still to the best position of equilibrium the field forces will permit. This also we have seen convincingly.

One thing I must emphasize. The field always is as unitary as conditions will permit. And a field is almost never symmetrical and uniform. All portions of the 'unexcited' visual field are not equally disposed or ready to take form or maintain a figure. Previous processes may have left long enduring states of electrotonus in local regions which make true form and space perception within such region difficult or impossible. How can one determine the presence, magnitude and extent of such field anisotropy? Never directly from the findings of the analytical examination and never directly from any known skills tests. This is because as Köhler and Wallach have shown the alterant effect of the field upon the probe body does not stand in direct relation. The means therefore of determining the anisotropic state is operational and differential. This is why so often the measures of phoria fail to agree. But the disagreement is not error. It is rather the empirical fact that from two poles or axes the index of space projection of a point or line may give <u>two</u> instead of a single vector point. No one should be disturbed over the above facts. The measurement of figural strength or weakness simply has to be done by taking into consideration the fact that this determination cannot be made by any known metric applied directly and alone to the figure process. The figure must always be treated <u>in relation to</u> the totality of the enveloping field. Since it is rare if ever that a total field contains <u>at first</u> a single locus of high potential and since it is well known that if there are two such loci of different potentials the spatial separation of the two regions will not be the same as if each we set in the same field singly.

Why does not the major figure component therefore cause all weaker secondary ones to flow into or amalgamate with it. Sometimes people complain of just this sort of thing. Print blurs and "runs together." The theory is offered here that in perfect phenomenal vision the field is stably structured in a ground that is essentially motor. This is in harmony with the statement in a previous paper that sensory process always upset equilibria; motor processes always tend toward stable types of organization.

The restoration of an approximation to "normal" vision by whatever means (lenses, training, or both) is ultimately a matter of reshaping the distribution of forces within the 'visual' field. But this field is not only visual. It is also largely auditory, tactual, motor or kinaesthetic. When, for example, we determined the span for digits aurally and found our adult subjects limited and weak in this function and when we trained them to increase the audio-vocal span sufficiently we got immediate and larger increments in the visual perception and reproduction of tachistoscopic digit patterns. I predict that as soon as suitable apparatus can be developed to control properly the impression of such patterns results will show large improvements over anything thus far attained - and let it not be forgotten that present results in visual form perception are the best the world has ever known, by far.

Köhler's concept of satiation relates to a change in the electrotonus of certain regions within the brain cortex. Prolonged and continuous excitation sets up a sort of hystersis effect in protoplasm which may be quite long enduring. Within the satiated region there is noted certain definite changes in the phenomenal behavior of figures delivered to this region subsequently. Contour lines are weakened, sizes are reduced or expanded and spatial position or disposition is altered.

I have changed acuity or resolution of 3 meter König bars from 164 centimeters to 240 centimeters in twenty minutes. Two days later increased it to 290 centimeters and on the third day to 324 centimeters. This was done with the large "green rings." The subject was a 17 year old girl whose problem was myopia. At her maximum König resolution we tested her for Snellen acuity at far

point. The finding was OU 20/38. What we had then was a hyperopic girl for König bars who was at the same time myopic for Snellen letters! From our point of view there is nothing strange or exceptional about such finding. In order to check this further I took her immediately to the tachistoscope room to measure her near and far point thresholds for form. With letters now so large that no acuity factor was involved and at long exposures (i.e., from 20 to 100 milliseconds) she consistently confused H and N, O and G and C, T and F, etc. She still "enjoyed" the characteristic partial form-blindness of the myope. And we were now possessed of the absolute information telling us the next training steps we must take if we want to bring her to the eventual maximum of visual proficiency of which she is capable.

It is entirely likely that the good and positive results secured by any visual training procedure are good in proportion to the types and amounts of changes produced in visual field by satiation. The number of persons who have clear understanding of the full meaning of this theory and its procedural demands is today small. The reason is that these types of researches are new, even in most of the laboratories. Every visual function must be reexamined in the light of the fact, for instance, that in the normal field the upper and lower and nasal and temporal retinas do not behave the same. Geometrical symmetry in the physical stimulus pattern is quite asymmetrical the instant the ray sheaf excites the retinas. This calls for new diagnostic means, and new ways of thinking in optometry and ophthalmology. It also calls for careful, patient and exacting research. The whole professional and commercial optical world should at once foster and support or make the active attack on the scores of problems which emerge upon even simple first order observations of these 'new-old' things in vision. I confess a certain pessimism. A few isolated investigators will carry on. But it will take years to reach the point which planned, implemented and concerted action could produce in a short time. In my opinion the practical consequences of Köhler's work will become more and more important as we become able to translate it into instrumental and procedural office practice.

I hope that Volumes 5 and 6 have given a stimulus to thinking in a somewhat new and different way about seeing. There are many in the world, of course, who have not the remotest notion of such a set of concepts. There are others who know and love the trail reaching forward into the unknown. These are the ones we address.

Volume 7 is planned to begin in November. It will deal with a subject which has been deeply embedded in my affections for a quarter of a century. Our topic is briefly if not adequately named Motor Theory.